SAFETY METHODS
IN
POWER SYSTEM CONSTRUCTION

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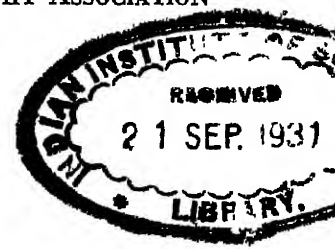
Prepared by the

ACCIDENT PREVENTION COMMITTEE
ENGINEERING NATIONAL SECTION
NATIONAL ELECTRIC LIGHT ASSOCIATION



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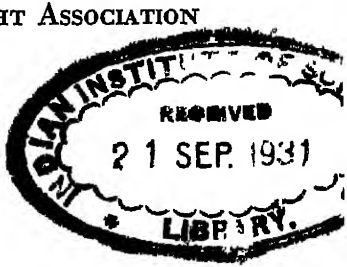

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Published by

NATIONAL ELECTRIC LIGHT ASSOCIATION
420 LEXINGTON AVE., NEW YORK, N. Y.

3496

1st Printing June, 1930—7500 copies
2nd Printing May, 1931—4500 copies

NELA Publication No. 045
Prices: 75c. to members; $1.25 to non-members
Printed in the U. S. A.—Federal Printing Co.

CONTENTS

FOREWORD

Construction supervisors, foremen and others who realize and desire to carry out their responsibility of providing safe working conditions, and of directing their men toward safe practices, will find many valuable suggestions in this handbook.

Published by the Accident Prevention Committee of the National Electric Light Association, the volume consists of reports of two N E L A subcommittees. Parts A, D and E (Electrical Construction Practices) were prepared by a subcommittee during 1925-1927, and were published originally as a Serial Report, Publication No. 278-44. Parts B and C and additions to Section I of Part A (General Construction Practices) were prepared by a subcommittee during 1928-1930. The personnel of these subcommittees (see page 197), included responsible supervisors of recognized authority, in charge of large construction projects, and designing and operating executives.

The subject matter, therefore, may be considered authoritative as to acceptable methods for safe performance of construction in electric utility properties.

PART A—GENERAL

Section I
ANALYSIS OF ACCIDENTS

Analysis of accident records is one of the most valuable aids to accident prevention. The facts revealed in this way not only point out the common hazards, but frequently indicate the most practical preventive measure. A proper analysis of accident records shows accurately the trend within a company from year to year, and provides a basis for comparing the effectiveness of one company's work with another's and with the industry.

Therefore careful record of all accidents should be a part of the prevention work of every company. Records should include all costs, not only wage compensation and medical costs, but incidental property damage losses if sustained. To compare frequency and severity of various classes of accidents requires the analysis of a large number of cases, so that conclusions may have the dependable basis of averages.

The New York State Department of Labor, Special Bulletin No. 126, is the authority for valuable conclusions based on thousands of compensation cases. These cases occurred in a variety of industries, yet it is believed that the conclusions are applicable to electrical construction and operation in utilities, because accidents which occurred in electrical and construction work in manufacturers' or utility plants form a considerable part of the report, and the causes of accident are often similar, regardless of place of occurrence.

Some conclusions from the facts in that report are:

I. During the handling of heavy objects there occurred over 10,000 of the 58,078 cases reported from July 1, 1922, to June 30, 1923. Accidents while handling objects rank first in frequency.

II. Accidents while hoisting caused 3 per cent of all

injuries; 4 per cent of permanent disabilities; 10 per cent of fatalities.

III. Falls rank second numerically, but caused four times as many fatalities as did handling objects.

IV. Accidents related to prime movers and power generation and transmission cause relatively few injuries, but of accidents so caused a high proportion results in permanent disability or fatality.*

Electric shock has a high fatality rate per accident, but by far the greater number of electrical accidents are burns which also have a high fatality rate.

V. Falling objects, collapse of walls and piled materials, falling trees and poles, and cave-ins, show a high fatality rate per thousand accidents.

VI. Hand tool injuries are frequent. While direct injuries are generally slight, the danger of infection with resulting permanent disability cannot be overlooked.

VII. Accident distribution by age shows greatest frequency at period from 20 to 30 years. After age 30, the frequency rate falls rapidly, partly due to acquisition of experience and careful habits, but also because of the lower percentage of older workers engaged.

VIII. Dismemberments occur most frequently under 30 years of age.

IX. Proportion of fatalities to accident frequency increases rapidly with age, due probably to lowered resistance and power of recuperation.

CAUSES OF ACCIDENT

A large proportion of accidents in electrical construction is preventable. No thorough study of causes can fail to impress this fact. Some causes have been cata-

*A large N E L A member company reports that a study of 10 years' record indicated that, while electrical accident cases were relatively few in number (approximately 8 per cent), yet they caused 75 per cent of lost time and fatalities Since that study was made, they developed precautions which successfully reduced the number of electrically caused accidents

logued elsewhere but are worth repeating, and a number have been added.

I. Supervision Failure:

1. Confusion in issuance of orders. (Ambiguity in use of English.)
2. Inadequacy of tagging or holdoff method.
3. Insufficient electrical clearance.
4. Insufficient mechanical clearance.
5. Inadequate guards and protections.
6. Failure to instruct workmen in methods or rules.
7. Incompetence of employe.
   (a) Physical incompetence. Fatigue. Sickness.
   (b) Mental incompetence.
   (c) Inexperience.
   (d) Carelessness (habitual).
   (e) Cocksureness.
8. Failure to follow proper holdoff method.
9. Failure to understand conditions or circuits, or function of apparatus control details.
10. Improper tools or devices.
11. Improper method of handling.
12. Protective devices not provided.
13. Protective devices provided, but not used.
14. Rules not followed.
15. Lack of proper inspection and maintenance resulting in failure of tools, materials, devices or insulation.
16. Poor light.
17. Disorder of premises.
18. Leaking fumes, gas, steam.

II. Employe Failures:

1. Mental condition.
2. Disobedience, willful.
3. Wrong use of tools.
4. Dropped material or tools.
5. Wrong method of handling materials.
6. Haste.
7. Poor judgment.
8. Pranks, fooling.
9. Slips, falls, strains.

III. Causes Beyond Control:

1. Abnormal weather conditions.
2. Flaws undiscoverable by usual inspection
3. Sudden physical collapse of employe.
4. Acts of persons not in employ of compan

It would be difficult to catalog under II, 1 Condition, all the possible causes. However, mention: Inattention to Orders, Intoxication, or Non-habitual Carelessness, Lack of Concenti Aberration, Overambition, Imitation without Kr Study of accident cause should include study o condition of all those involved.

Fatigue

A certain degree of fatigue is the normal bodily activity and is harmless. However, whe reaches the point where complete recuperation take place within a reasonable rest period it harmful. Such exhaustion lowers the physical ar efficiency and gradually undermines the health. fatigued body generates poisons (toxins) fas they are dissipated and literally becomes poison

Mental and nervous fatigue may be the unusual strain due to work, living conditions, sonal habits. Worry over personal business, sic conditions on the job lead to nervous fatigue, a be carefully avoided. Workmen showing signs nervousness should not be assigned to tasks h element of danger in them.

Medical examinations of the blood, urine, been devised for detecting fatigue, but a more c method is by observing outward symptoms. persons are inattentive, listless, and slow to r instructions or warnings. The senses act mo and consequently the ability to work safely is r

Important rules in preventing fatigue are:

I. Reasonable working hours with regular rest periods.
II. Avoid continuous heavy work for prolonged periods.
III. Set a maximum limit on overtime work.
IV. Limit complicated tasks requiring both physical and mental labor.
V. Provide good ventilation and lighting.
VI. Insist on healthy workmen. An unhealthy body is easily tired.
VII. Reduce anxiety or worry. It increases both physical and mental fatigue.

The effect of fatigue on time of accident occurrence is shown in Fig. 1.

The type of these 232 accidents constituting one year's experience for a group of 705 electrical construction workers, is shown in Table I. Both lost time and non-lost time accidents are included.

The effect of type of work during the progress of a large power station construction project is shown in Fig. 2. Both lost time and non-lost time accidents are included.

ACCIDENTS HYDRO-ELECTRIC CONSTRUCTION

This analysis shows by the frequency rate curve that accidents were more frequent during the earlier building period. This must have been partly due to the number of unseasoned workmen employed. Another period of high frequency occurred during the installation of machinery, but here again the working force was suddenly increased so that unseasoned workmen must have been a contributing cause. When a large number of men were employed, the frequency rate seemed to vary as the man-hours worked varied, but when only a small force was working the rate was very irregular.

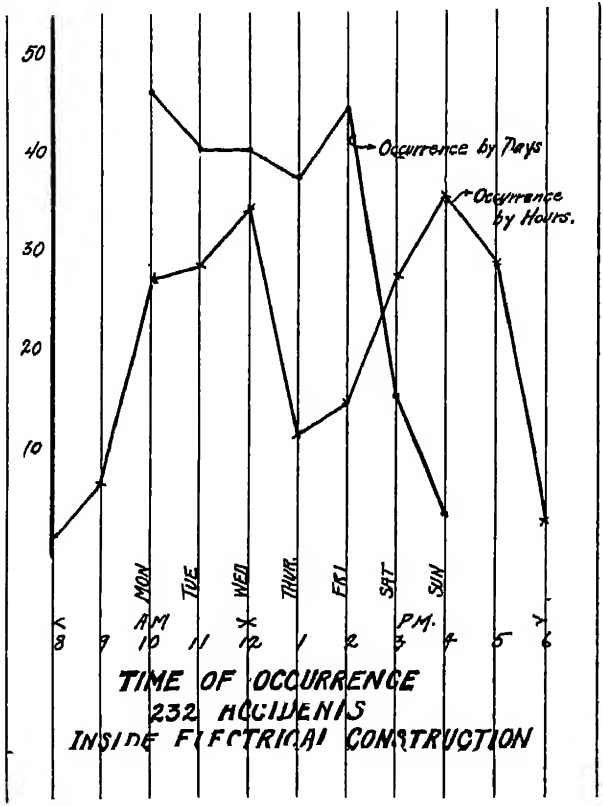


Fig. 1—Accident Occurrence by Hour and Day—Inside Plant Electrical Work.

Table I—Year 1925—Accidents, Inside Electrical Construction.

Type Accident	System Field Construction	Machine Shop	Riggers	DC/AC Change Overs, High Voltage Tests Inspections Repairs	Total
Burns, electric	2	0	0	1	3
Burns, miscellaneous	14	0	0	3	17
Carelessness	44	1	3	19	67
Defective tools	1	0	0	0	1
Electric shock	1	0	0	0	1
Eye	12	2	1	1	16
Fall	2	0	0	2	4
Falling objects	4	0	2	0	6
Handling materials	22	1	1	4	28
Handling tools	16	0	1	0	17
Nails	7	0	0	0	7
Overcome by gas	2	0	0	0	2
Slip, trip	8	0	0	2	10
Strain, sprain	22	0	1	4	27
Unavoidable	17	0	1	7	25
Unguarded openings	1	0	0	0	1
Total accidents	175	4	10	43	232
Average number employees	367	22	12	304	705
Accidents per 100 employees	46 4	18 2	83 3	14 1	32 9
Manhours worked	863,000	55,000	30,000	760,000	1,708,000
Manhours lost	2,496	0	0	640	3,136
Hours lost in per cent	0.26	0 0	0.0	0.08	0.183

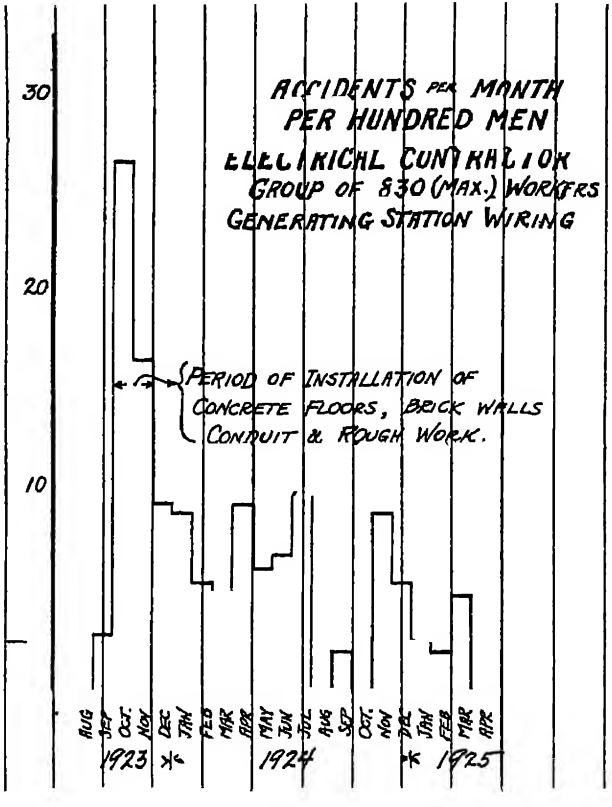


Fig. 2—Accident Frequency by Time, Generating Station Construction.

This analysis also shows that the severity of the accidents bears no definite relation to the number of men working, but is influenced more by the nature of the work being done. It should be noted, however, that the deaths which occurred on this job resulted from accidents on work which would not be considered especially hazardous. Figs. 3, 4 and 5 show the accident record of a large hydro-electric project.

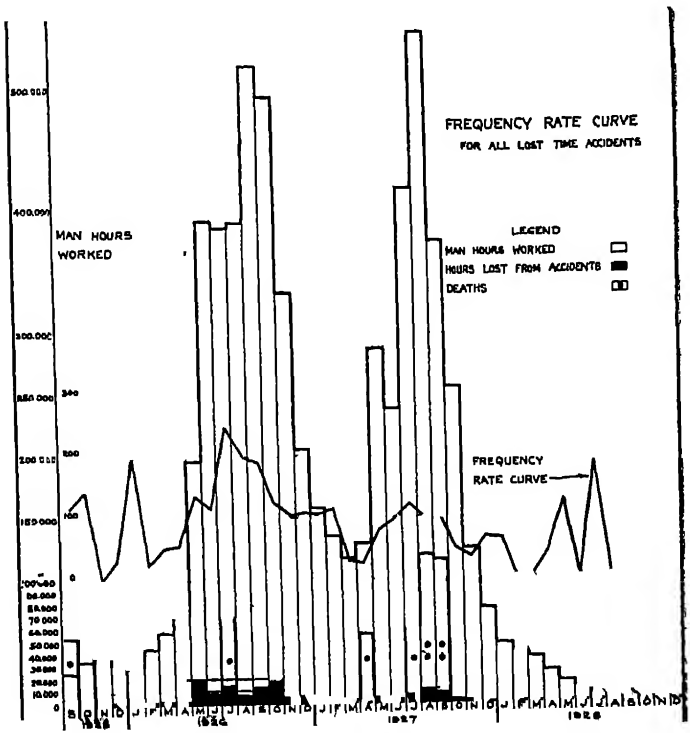


Fig. 3—Showing Relations of Man-Hours Worked, Time Lost, Deaths and Frequency of Accidents.

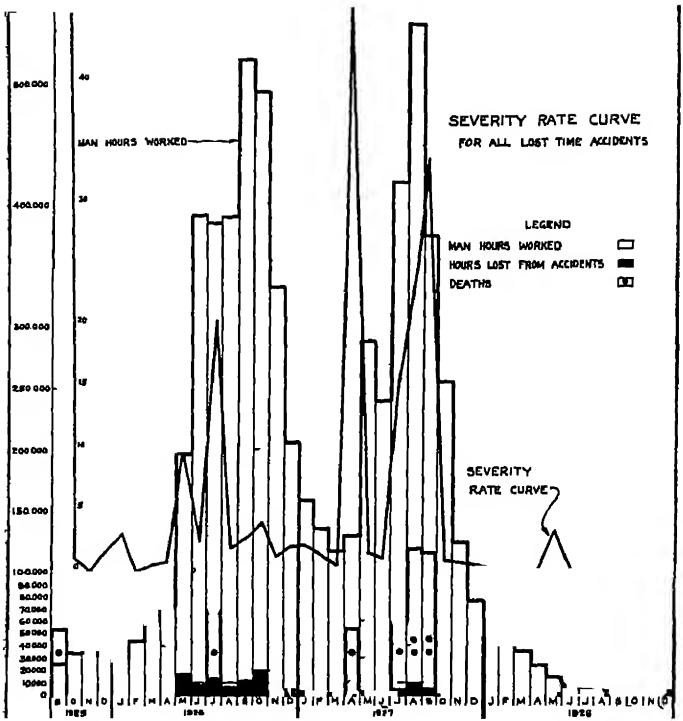


Fig. 4—Showing Relations of Man-Hours Worked, Time Lost, Deaths and Severity of Accidents.

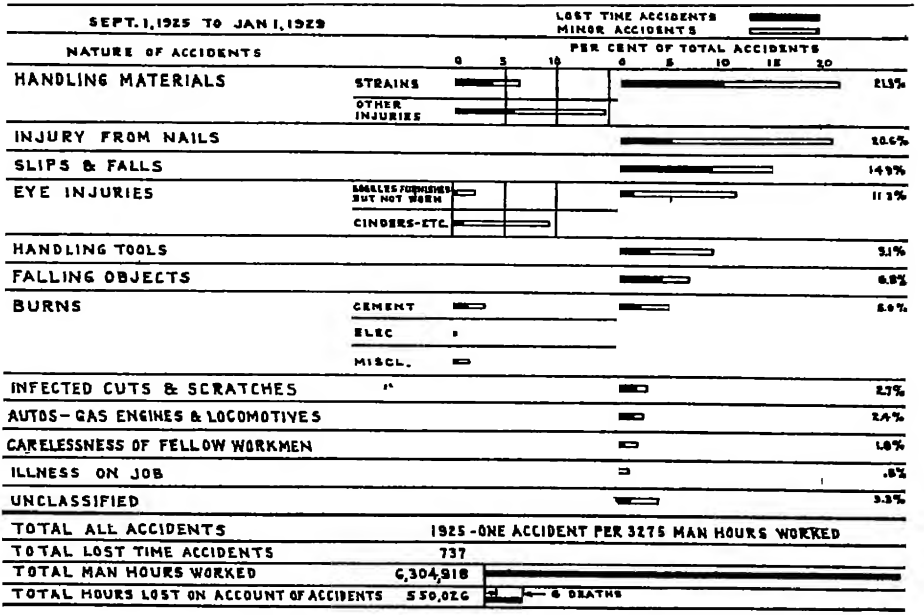


Fig. 5—Classification of Accident Causes.

Section II

TOOLS

Every type of construction tool, including power-driven machine tools, presents a hazard. The counteracting or diminishing of tool hazard is largely dependent on the knowledge and ability of the users of the tools.

Classification by Function

In analyzing the kinds of injuries caused by use of tools, it was found that tools may be classified according to functional uses which carry distinctive kinds of hazards.

I. Cutting

The edged or cutting tool accomplishes its task by removal of material by a sharp edge, cutting or splitting the material being worked. In this class are axes, bits, chisels, planes, saws, knives.

II. Percussion

Tools employing successive blows can be classified as percussion type, including hammers, rams, tamp-bars. Axes and picks use both cutting and percussion force.

III. Abrasion

In sharpening edged tools, smoothing rough surfaces, or reducing dimensions, abrasion tools, such as sandpaper, grindstones, emery wheels, files and scrapers are in use.

IV. Leverage, Torsion, Friction

Braces and screw-drivers use torsion and leverage. Wrenches and crowbars use leverage.

V. Heat

Heat is applied directly by forges, torches or arcs, or indirectly by soldering irons, melted solder, induction, etc.

VI. Machine Tools

For application of larger amounts of power, the machine tool is designed, using combinations of some of the above functions. Circular saws, lathes, drill presses, etc., use torsion and cutting. Boring machines, planers, shears, etc., use cutting and leverage.

VII. Miscellaneous

Many tools such as ladders, rollers, buckets, hoist tackle, etc., are not so easily classified.

List of Tool Hazards

With knowledge of the kinds of forces involved, the kind of accident which can be caused may be anticipated and preventive precautions used.

I. **Cutting and skin abrasion hazards** are inherent in the use of adzes, axes, knives, chisels, saws, shovels, etc., due to their sharp cutting edges.

II. **Skin abrasions and blisters** are caused by roughened and split handles of braces, drills, screw-drivers.

III. **Bruises and pinches** are caused by hammers, pliers, mushroomed drills, loose heads of percussion tools.

IV. **Pinches, punctures and strains** are caused by slipping of leverage tools, like screw-drivers, crowbars, pinch bars.

V. **Entanglement of clothing** with serious resulting accident may be caused by catching on moving parts of machine tools.

VI. **Crushing of members** is common in use of rollers, slings, skids, cranes.

VII. **Punctures** are often due to tools with tangs used improperly without handles.

VIII. **Burns** are caused by careless use of furnaces, forges, torches, solder pots and irons.

IX. **Bruises** caused by dropped hand tools are common because of careless work on scaffolds, ladders, poles, step-ladders.

X. **Falls** from scaffolds, ladders are due to insecure supports, footings and rails, defective ladders, etc.

XI. **Tripping** is frequently caused by hand tools, rollers, snakes, ropes, etc., lying loose on walkways.

XII. **Eyestrain, insufficient vision** due to intense glare, or inadequate lighting causes trips, falls and other mishaps.

XIII. **Electric shock** due to grounds in portable tools is much too prevalent. At the 1926 National Safety Congress in Detroit, over 75 fatal low voltage (750 volts or less) shocks were reported as having occurred during recent years, many of them in the use of portable tools.

Care and Selection of Tools

The following precautions will eliminate many of the hazards ordinarily encountered.

I. Supervision

It should be a matter of routine duty on the part of superintendents and those in charge of construction work to enforce rules appropriate to each working condition and to assure themselves that tools in proper and safe condition are used in the execution of work for which they are intended.

II. Selection of Tools

The selection of tools for all classes of work should be such that a very high grade of workmanship and material will be incorporated in their manufacture.

III. Check Tool Results

Foremen should at sufficiently frequent periods, as a matter of routine, report the results from the use of special tools and appliances frequently accompanying apparatus of various types and makes, with the object in view that these special appliances and tools be improved and made more suitable and safe for the purpose for which they are designed.

IV. Inspection on Return Before Re-issue

Storeroom or tool room clerks should be specifically instructed that, on receiving returned tools for storage or checking in, they be inspected with respect to their safe condition for use, and if in any way defective or unsuitable for safe and efficient work they should be tagged as defective, giving details of defects. They should not be re-issued, but reported to foreman or superintendent, and either repaired if possible or scrapped and replaced with new tools.

V. Tools for Live Work

Where necessary that work be done on live parts of electrical apparatus or in connection with electrical circuits at or below voltages safe for such work, properly insulated tools, which have been thoroughly tested to determine the condition of their insulation, should be used. It should not be a practice to permit use of this class of tools except for this specific kind of work, and only by authorized employes and under carefully planned procedure. Employes should not place sole reliance on insulated tools, but should also be required to wear tested rubber gloves. Gloves are dependable except when weakened by aging or by ozone liberated due to corona, or by mechanical injury. Insulated stools having four feet, rubber protection, etc., are advisable also. Special precaution in covering conductors of different polarity should be observed.

VI. Tools Owned by Employes

Instructions should be issued to all foremen, superintendents or those directly concerned with the hiring of mechanics or other artisans who may bring on the site of the work tools which are their personal property, that these tools, particularly lineman's belts, should be inspected before the workmen are permitted to use them, and monthly thereafter.

VII. Work by Contractors

Where work is being executed by contractors under

any condition of contracting relation with the company, the company should incorporate in contracts provision requiring inspection by the contractor of his equipment and tools, and the contractor should not use unsafe tools or equipment.

VIII. Portable Electric Tools

Defective insulation of portable tools may cause shock, which, even if not severe enough to injure electrically, might cause falls from ladders or scaffolds. However, many low voltage shocks have proved fatal. For this reason a frequent insulation test of all portable electric tools is imperative.

Conducting cords insulated with an extra high-grade rubber are desirable. Such cords are durable mechanically and afford better insulation than cheaper grades.

Lamp guards of fiber are preferable to guards having metallic parts.

IX. Rubber Gloves

Rubber gloves and protectors should be periodically tested in laboratory and records of issuance and return be kept. Defective gloves may have a "V" cut in the cuff, or have the thumbs cut off, to insure against their being used for voltage protection, yet keep them available for other work not requiring insulation.

Tests should be applied after each extensive use of gloves, regardless of normal retest periods.

Some companies require monthly retest of gloves intermittently used, and bi-weekly tests on gloves used frequently, with provision that men may request tests as frequently as they desire, having spare gloves available in the field. Specification D120-23 of the American Society for Testing Materials is basis of tests. Working voltage limit recommended for gloves so tested is 8,000 v to ground.

Several companies require use of gloves on *low voltage live work.* Experience indicates that men dislike to use gloves, not realizing the liability of fatal shock at low

voltage. Gloves so used receive hard treatment. Left hand gloves show greatest wear and failure on retest. To counteract the tendency of men to discount the necessity of gloves on low voltage work, gloves returned to laboratory are inspected for obvious injury, which should be apparent in the field on air compression test. Compression test by storekeeper on issue and by men before use is frequently met as a requirement. Breakdown tests at 3,000 v are made on gloves to be used on the low working voltages. Any gloves failing to pass either the inspection or the 3,000 v test are held to be potential death hazards, even on low working voltage. Therefore, the man and foreman who allow such deterioration to go unreported are severely reprimanded and repetition is a serious offense.

The use of leather protectors is growing in favor on account of the volume of mechanical injury, especially to gloves used on low voltage.

The NELA Meter Committee's Report, "Inspection, Retest and use of Electrician's Rubber Gloves" (Publication No. 055), and the National Safety Council Public Utilities Section pamphlet No. P.U.3, "Testing, Care and Use of Linemen's Rubber Protective Equipment", are both good references on the subject of rubber gloves.

X. Linemen's Tools

See Section XIII.

XI. Scaffolds

Scaffold accidents, when they do occur, are liable to result in fatalities. The following is quoted from New York State Department of Labor, Industrial Code Bulletin No. 23. "Rules Relating to the Erection, Repair or Demolition of Buildings."

Scaffolding or staging more than 20 ft. from the ground or floor, swung or suspended from an overhead support or erected with stationary supports, except scaffolding wholly within the interior of a building, and covering the entire

floor space of any room therein, shall have safety rail of suitable material properly attached, bolted, braced and otherwise secured, rising at least 34 in. above the floor or main portions of such scaffolding or staging, and extending along the entire length of the outside and the ends thereof, with only such openings as may be necessary for the delivery of materials. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or structure.

All scaffolding shall be so constructed as to bear four times the maximum weight required to be dependent therefrom or placed thereon when in use.

Rule 1220. *Swinging Scaffolds*

(a) Fittings: 1. Every scaffold, swung or suspended from an overhead support, which is ten (10) ft or more above the ground or floor, shall have a railing of wood not less than one and three-quarter (1¾) in. by two and three-quarter (2¾) in., or other approved material of equal strength, properly secured at intervals of not more than twelve (12) ft, such railing to be at least thirty-four (34) in. above the floor or floors, or main portion of scaffold and extending its entire length.

2. A toe board of wood not less than four (4) in. in height shall extend along the outside of the scaffold and shall be secured thereto.

3. Such scaffold shall be not less than twenty-seven (27) in. in width and have supports or hangers at intervals of not more than twenty-two (22) ft. Hangers shall be of either iron or steel, of one continuous piece and of such construction that the platform will rest on the hanger. A life line shall be provided.

4. Rope or ropes used for supports shall be manila or cotton of the best grade, not less than three-fourths (¾) of an inch in diameter, properly spliced into standard six (6) in. ball bearing, roller bearing or bush blocks. Steel cable of approved strength with approved blocks may be used.

5. All ropes, cables and blocks supporting scaffolds shall be capable of sustaining at least four times the maximum weight of the material and men to be placed on the scaffold.

6. All ropes shall be carefully tested before each operation and every thirty days thereafter, if the operation ex-

ceeds that period of time. A record of such test shall be kept, such record to specify the time and place of the test and the names of at least two persons witnessing the test.

7. All iron work shall be of the best grade and the forging done with care and tested before being used.

8. Means shall be provided to prevent scaffold from swaying.

This bulletin also contains other details for various scaffolds for special uses.

XII. Ladders

Reference is made to U. S. Bureau of Labor Safety Code, Series 351, "Safety Code for Construction, Care and Use of Ladders."

The Great Lakes Section, N E L A, Committee on Accident Prevention prepared recommendations on ladders, which are the bases of the following notes:

I. General

The ladder should be of sufficient strength to resist safely double the strain of the heaviest load that will be placed upon it in use. This has been assumed to be about 450 lb—the weight of a man and the burden he might reasonably be expected to carry up or down a ladder, and a like weight added as a margin of safety.

The ladder must be wide enough for the user to move freely and safely about his work.

II. Clearances

In back of ladder. A continuous clearance space should be provided back of the ladder rungs. The depth of such a clearance should be sufficient to allow a person's foot to obtain a fair purchase on the rung, as a slight obstruction to foot or hand in gaining a hold on a rung may cause a misstep, with serious results. For this reason general practice favors a minimum clearance of 8 in., and some authorities even favor allowing a minimum of 12 in.

In front of a ladder. A continuous clearance space should be provided in front of the ladder, so as not to compel a person to assume a cramped or unnatural climbing posture. Fixed objects projecting at random too close to the front of a ladder may strike and injure the person climbing it,

or they may catch the clothing of the climber and jerk him loose from his hold. To eliminate such a hazard, some requirements provide for a minimum clearance space of 24 in., but 30 in. to 36 in. seems to be more generally favored, and would, undoubtedly, be safer, because a workman often carries tools projecting from his pockets or tool belt that would not pass a 24-in. clearance.

Side of ladder. It is evident from the foregoing discussion that it is important to have a proper continuous clearance space on each side of the ladder. Generally conditions would be satisfied with a 15-in. continuous clearance space on each side of the center line of the ladder.

III. Use

One man on one ladder at one time. If ladders are used as a common passage-way, provide one (or a group) for ascending, and another (or a group) for descending—if of a permanent character, stairways should be constructed.

IV. Ladder Construction of Steel or Iron

Permanent types of stationary ladders should be constructed of steel or iron and should be designed effectively to resist the impact blows of falling materials and loads swinging from cranes, slings, etc.

Ladders having side rails and fastened top and bottom, with intermediary supports, are preferable to the built-in type consisting of "U"-shaped sections imbedded into wall or fastened to stack

Side rails of angle steel or iron should not be less than three-quarters (¾) of a square inch in cross-section. A size of two (2) in. by one-half (½) in. should be used.

Ladders designed to reach safety valves, cut-outs, etc., where speed of operation may mean saving of life, should always be of permanent type—securely fastened and constructed entirely of steel or iron.

V. Wood

Temporary stationary ladders, as well as ladders of portable classifications, are usually constructed of wood. Thoroughly seasoned long-leaf yellow pine, Oregon fir, or northern white spruce is used with good results for side rails, and white ash, oak (second growth) or hickory is used for rungs. All material should be free from knots or shakes,

although ½-in. imperfections are sometimes allowable in side rails of the larger sizes of ladders if in center of stringer.

VI. Rungs

The rungs should be designed as a simple beam supported at both ends to resist safely, without permanent or readily apparent deflection, the stresses incurred by a load equal to the weight of an average man imposed at the center of rung. To this must be added any weight carried or supported by man on the ladder. Another condition also controls the minimum section of a rung, i.e., a diameter that provides the most secure hand hold. Such precautions as (1) having all the rungs in a ladder of uniform section is a good idea, as it eliminates the annoyance of varying the grip with each rise; (2) having rungs of ladder free from splinters, if wood, and burrs, if steel, may seem of minor importance, but experience has shown that such small annoyances to the climber cause many a misstep and fall; (3) spacing of rungs should be uniform. General practice favors a stringer spacing varying from 15 in. to 18 in.; for metal construction a round steel or iron rung varying from ⅝ in. to 1 in. in diameter; and for wooden construction a rung of not less than 1⅛ in. in diameter, tapered to fit a somewhat smaller socket, will conform to safe practices.

Excellent wooden rungs are made from blocks sawn to proper length. If of white oak, blocks may be split and hand-shaved to size, and the ends machine turned to fit sockets in stringers. Hickory or white ash will not split evenly, and machine turning will be necessary, and, consequently, careful selection should be made of material and careful inspection and testing made to avoid weak rungs. Wood rungs may be reinforced and stringers tied together by tie rods. See last paragraph of Section II.

VII. Non-Slip Bases and Safety Tops

Probably no other one device has called forth so many attempts at guarding as have the bases of portable ladders. For wooden floors, metal points or lead-coated bases are recommended; for use on iron floors carborundum has been found to serve very well. One state (Pennsylvania), however, specifies the placing of an attendant at the foot of

each ladder when working on iron floors. For concrete floors, pivoted lead shoes or carborundum is recommended. For wet floors, recessed rubber bases have given the best satisfaction.*

However, the only safe practice is to station a man at the foot of the ladder or to tie it securely—or both. We cannot depend on any one type of base under all conditions and be safe.

Safety tops are provided for fixed ladders by running the stringers shoulder-high above the highest level where work is carried on. A "goose-neck" permits a higher degree of safety.

Oilers' ladders, with hooked tops to fit over shafts, are becoming more and more the rule.

VIII. Stationary or Fixed Ladders

Safe practices, applying to stationary or fixed ladders, include the following: When sections join, splice plates shall be of same size and material as side rails and carefully riveted or bolted. Wooden ladders may be spliced with steel braces of equivalent strength.

Ladders over 20 ft in length should be built in zig-zag sections and provided with safety platforms.

Brackets should be of suitable strength to support firmly the ladder and weight of workman and burden, and should be of sufficient rigidity to resist any anticipated impact from falling material or traveling crane. Brackets should be fastened by through or expansion bolts firmly imbedded in wall. Brackets or braces should not be spaced in excess of 12 ft.

Rungs should be omitted above work level and the side rails carried three feet higher and, if of metal (preferable), terminated in a "goose-neck." No open space of more than 18 in. back of the ladder should be tolerated at landing.

IX. Temporary Stationary Ladders

Ladders of this type are often used during the construction of buildings and are usually made on the job of rough or used material. Side rails are often faulty and rungs are pieces of rough boards nailed on and more or

*Pivoted cork feet have been found very successful in resisting slip on concrete or wet floors, even with ladders placed at wide angles from vertical wall—Accident Prevention Committee

less unevenly spaced. Such ladders should never be used, unless it be on an emergency job and the ladder first passes the inspection of a competent person. It is probable that such construction has been the cause of more ladder accidents than all other causes put together.

Safe practice demands that all ladders be carefully made of selected side rails with rungs that pass through or are recessed into side rails and securely fastened in position by tie rods. See last paragraph of Section II.

X. Portable Ladders

Convenience limits the length of portable ladders to approximately 30 ft.

Ten-foot ladders, constructed of northern spruce side rails (or wood of similar strength) will be found satisfactory if of 1⅜ x 2⅜ in. material; 18-ft, 1⅜ x 3¾ in.; 25-ft, 1⅝ x 3 in.; 30-ft, 1⅞ x 3½ in.

Rungs of 24 in. length seasoned ash should be 1⅛ in. with tenon of ⅞ in.; over 25 in., 1¼ in. with tenon of ⅞ in.

Safety tops, non-slip bases, lashings and attendant, each is necessary to meet special conditions.

Width at bottom of most types of portable ladders should be appreciably greater than at top.

XI. Step Ladders

Unlike other forms of portable ladders, the step ladder is intended to be used as a working platform at any one of the several steps or planes provided. Safe practices demand, therefore, exceptional care in providing both strength and high degree of rigidity in construction as well as a solid foundation.

Step ladders should never exceed 20 ft in length and have side rails from ⅞ in. x 3 in. to 1 in. x 4¼ in., the latter being used as the limit of length is approached. Steps vary from ¾ in. in thickness to 1 in. for the heavier types and a slight increase in width is also recommended in very long ladders over the 4¼ in. of the shorter ladder.

For every foot of length the bottom of a step ladder should be 1½ in. wider than the top. Steps must afford a safe foothold and should be trussed, braced or reinforced, and must be securely screwed or bolted to side rails.

An automatic locking device (or spreader) to hold front

and back rails securely in position should be an integral part of each ladder. The locking device should have a shield to protect the hand.

Steps of this ladder are often covered with non-slip material. For electricians' use this non-slip material should not conduct electricity. Many companies omit top platform. Tool shelf is sometimes provided with a tool-retaining curb. Some companies will not use commercial step ladders, but have specially designed ladders built with extra heavy members. One company uses full weight rungs on rear stringers to permit two men on opposite sides of ladder.

XII. Extension Ladders

Safe practices for extension ladders must provide for additional strength in lower section. This provision is intended to cover stresses peculiar to such construction.

Locking device should be simple in operation and positive in action and of steel tested for imperfections. Device should be securely fastened to stringers.

Safe foundation for this type of ladder is imperative.

XIII. Trestle Ladders

Safe practices demand tests similar to other portable ladders as to weight of workman, etc., together with allowance for material waiting for use in construction.

Trestle ladder steps may be staggered so that planks may be quickly adjusted to desired height.

Trestle ladders should not exceed 14 ft in height, and when in use should have a spread at base of from one-third to one-half height of ladder, and careful attention should be given to placing of ladder to insure safety during operation.

Hinges should be of wrought or malleable iron, bolted or riveted to side rails

No material or weight should lean against trestle ladders.

Two-inch planks should not be allowed to project more than 1 ft beyond scaffold ladders, and 1-in. boards not to exceed 6 in. Unless the planks or boards be of considerable length a workman stepping on the exposed end will be liable to tumble.

The old-fashioned trestle ladders are being supplanted by the Extension Trestle. The latter has been tested and approved by the Underwriters' Laboratories.

XIV. Safe Practices

Use care in placing ladders before using ther
ladder should not be placed nearer foot of wall
surface than one-quarter the length of ladde
more than one-half length away. If there is
ladder slipping have someone hold it. Do not pl
too straight or at too great an angle or they may
or slip.

Never place ladders in front of doors open
the ladder.

Ladders should never be placed against wind
Screw a board across top of ladders to give
each side of window.

Step ladders should be fully opened out in al
fore anyone steps on them.

Always face ladder when ascending or descen

Do not go up or down a ladder without free
hands. If material has to be handled use a rope.

Never slide down a ladder.

Never use broken or weak ladders or ladders
ing rungs.

When defects of construction develop to such
that the ladder is discarded, it should be destroy

Ladders withdrawn from service for repairs
sent to repair shops or tagged as "Dangerou
Use."

See that ladders you use have safety feet,
necessary, safety hooks at top. "Sharp metal
prohibited in some establishments. Others urge

Short ladders should not be spliced togethe
are not built strong enough to be used as long

Safe practice demands that ladders be subjected
and periodic inspection.

Ladders should be kept clean and free from dirt
ings of paint or material. Imperfections or defe
readily observed unless ladders are kept in good

Iron and steel ladders should be coated wi
servative consisting of a coat of linseed oil. W
ders, if used out of doors, should also be careful
with a suitable preservative such as varnish or o
paint wooden ladders.

A satisfactory practice is the storing of lad

brackets by arranging against wall in such manner as to permit inspection without moving ladders.

Storage of ladders involves a separate problem. Shelter should be provided in all cases. If placed upright 75 deg will afford safe angle; if racks are used, place ladder on edge rather than flat—this will prevent trouble and danger of accident in withdrawing ladder for use. Safety belts and hooks should be provided when the character of the work demands the attention of the workman or constitutes an element of danger.

The above notes cover ladders for general use. When ladders are to be used in live stations they should not have metal rung braces, trays or struts on account of the danger of short circuits or accidental contacts with live parts. (See National Electric Safety Code, Rule 422-A-6.)

Section III
BARRIERS, PROTECTORS, INSULATION, CLEARANCES

For work near live lines and apparatus, protection is assured by use of barriers.

I. Barriers

In operating stations, materials should be preferably non-inflammable. Metal screens of bronze, brass or iron (if permissible) are used when open ventilation is required. The mesh should be small enough to prevent long tool handles, etc., entering inclosure. When metal rods, pipe and tubing must be moved about, solid barriers are preferable. Transite board or similar material is desirable for this purpose.

Many companies use compartment doors for oil circuit breakers, reactors, regulators, transformers, etc., of transite board, and equipped with the series lock system arranged so that they cannot be opened until circuits are killed.

High voltage test sets are screened with locked doors or gates which cannot be opened until test current is off and static charge has been removed by grounding.

Battery rooms are often locked and should be vented to prevent accumulation of explosive gases. (See N E S C, Sect. 13.)

Floor and wall openings, pits and wells should be barriered during construction. (See N E S C, Rules 104 and 105.)

II. Protectors

See detailed descriptions and notes under Overhead Line Work (Section XXXVII).

The use of rubber mats, blankets, gloves, etc., is indorsed. It is the feeling of many supervisors, however, that for inside station work main reliance should be placed on gloves frequently and thoroughly tested in laboratory, and on constant care rather than on rubber blankets, and pigs, insulated stools, etc., which may become damaged in use.

It is also preferable when possible to use solid materials as barriers so fastened as to prevent dislodgment rather than rubber blankets which may become displaced

III. Insulation

Designs should provide adequate insulation of permanent equipment in accord with recognized engineering standards. Current carrying cables and buses, though insulated, should be treated as alive. (See N E S C, Rule 420F.) We will, therefore, confine this report to a recommendation that for all temporary wiring and protection in construction, insulation and protection of insulation should be of equal value with permanent standards. Sometimes conditions even necessitate extra insulation and protection against moisture, fumes, etc. Cable ends which are left idle (in manholes) should usually be test capped for full test voltage. (See N E S C Rule 155.)

IV. Clearances

See N E S C, Rules 114, 115 and 422.

National Electric Safety Code, Rules 422B and 422C, states minimum clearances with reference to voltages.

New station designs will doubtless use adequate clearances. However, in old plants, and sometimes in new plants due to unforeseen conditions, there will be found clearances of less than adequate amount for safety to workmen.

It is recommended that all foremen be provided with N E S C tables of necessary working clearances and be required to check all work in live stations. No work should be allowed with less than safety clearances around or under conductors. Realization that arcs and flames as ionizing agents may cause conducting paths in gases is necessary on the part of working forces. (See N E S C, Rule 174.)

Section IV

HOLDOFFS

(*See N E S C, Rules* 420 *to* 424 *incl.*)

There is no more effective guard against serious electrical, steam, water and other accidents than a simple, well-administered holdoff system. Several references to this need will be found in other sections of this study of hazards in electrical construction.

Design of apparatus and switching systems has brought complications, not provided for in the older "tagging" systems, which were designed for simple absolute holdoff. Old rules are often utterly voided by requirements of new designs. Vigilance is required to prevent misapplication of existing rules. Great concentration of power often renders the effects of mistakes disastrous.

In the following pages attempt is made to indicate underlying principles of protective holdoff systems, which are applicable to large and small generating and distribution systems. Statement of principles rather than detail of application is the aim. A considerable number of operating, construction and distribution people have approved these principles.

The universal adaptation of such methods of holdoff as are here outlined would carry the advantages of (1)

simplifying operation when new interconnections and joint operation of systems are made; (2) a common usage and understanding by employes who may shift employment; (3) some tendency toward standardization of design, since protection features secured by detail of design and by holdoff systems are mutually dependent; (4) improvement of existing inadequate systems and reduction of hazard.

I. Object

The purpose of holdoff systems is to prevent improper application of voltage to a circuit or making apparatus alive, on which men may be working, or which is not in condition for regular operation.

II. Requirements

A satisfactory system should possess as many as possible of the following features:

1. Simplicity.
2. Readiness of application.
3. Means of recording essential facts (see below).
4. Absolute inviolability of holdoff.
5. Means of allowing modified holdoff. (Tests, etc.)
6. Safe means of applying grounds, locks, blocks.
7. Auxiliary warning placards.
8. Clear, unmistakable significance of signs and tags and warnings.
9. Visibility and security of placement of signs, tags and warnings.
10. Ritual for telephoned requests to insure repeat and thorough understanding.
11. Responsible administration (generally by System Operator).
12. Receipt stub or copy of holdoff order containing duplicate record of facts to be given person to be protected, after precautions are complete.
13. Means of separately superimposed and recorded holdoff for every separately responsible individual, or gang foreman, working on protected circuit.

14. Means of instruction and periodic exa
the proficiency of every individual wl
the holdoff system; information pre
sented in an instruction book to be r
by employe.

III. Outline of Holdoff Systems

Scheme A. This is a composite of the go
of several companies. All these features are i

1. Request for holdoff is made to Syste
Written request 24 hr in advance is requir
emergencies.

2. Log Record is kept by System Operator,
receiving a serial number. Facts entered arc
   a. Full name of individual requesting pr
   b. Date and hour of receipt of request.
   c. Station, apparatus and circuits to be w
   d. Station, apparatus and circuits held o
      those listed under 2c. (above).
   e. Duration of holdoff if limited as to
      hours.
   f. Reason for holdoff; work to be done.
   g. Name of person issuing and responsil
      off, and for locking, blocking and grc
      placing holdoff signs and warnings.

3. Carbon Copy or stub record of above da
if possible, or in any event promptly sent to
tected as a confirmation and guarantee o
When copy cannot be delivered personally, t
ing means of check, telephoned requests an
repeated back by ritual and checked when
two persons at each end. After all precauti
plete, the copy is then issued indicating tha
are safe for work to proceed. (See NES C,

4. Protected person checks precautions, if
then proceeds with work.

5. Completion of work having been accon
person protected signs and returns his copy

to operator that this item of work has been finished, men are clear and service may be safely restored, after *all* outstanding holdoffs have been returned. (See N E S C, Rule 421E.)

6. Log record is kept also by substation operators remote from central load dispatcher.

7. Remote work in locations like consumer vaults, cable manholes or on transmission lines, depends on telephoned communication. Repeat ritual and written confirmation of orders should be made.

8. Cancellation of holdoff should be possible only by order of person whose name is indicated on holdoff card as the man protected or responsible for work being done, and only by his return of holdoff card properly signed. Exception may be necessary in rare cases in event of absence or incapacity of protected person. In such case full responsibility for ordering holdoff cancelled may be assumed, after check of conditions, by an authorized superior of high rank over the person protected. Such authority should be possessed by but few officials and their identity posted with system operator.

9. Duplicate holdoffs being held by several foremen working on same circuit offer a hazard. It is essential that record be so kept and holdoff signs so attached that service will not be restored or circuit energized from any source before *all* foremen have turned in their stubs or receipts, or, if remote from System or Station Operator, before all have given the telephoned ritual declaring the work finished and their gangs removed from possibility of contact with the circuit.

10. Check before cancellation of holdoff should be made to determine that no tools, rubbish, grounds, loose parts or improper conditions of mechanism exist, which might cause damage or accident. After such examination, foreman then removes gangs and arranges to cancel holdoff.

Scheme B. Contrasted with this somewhat elaborate system is the older, simpler system still in effect in many of the larger and most of the smaller companies, of hav-

ing a single red tag or holdoff sign. Originally on strictly radial systems this sign was used to protect linemen working on a single radial circuit or on steam valves to protect boilermen replacing tubes, etc.

With the control of all moves concentrated in the hands of system operator, this system has had an honorable record of service. It does, however, place a tremendous responsibility on the system operator when the system design departs widely from radial connections, and various ring buses, and inter-connections and back-feeds are used.

Further, when various systems of fault location and high voltage tests are used, this single sign can no longer hold its former inviolable protection significance.

Whether this or a more elaborate system of holdoff is used must depend on the judgment of those responsible for design and operation of systems, with due regard for methods of handling the system.

IV. Holdoff Accessories

1. *Signs* (tags, holdoff cards, etc.). In addition to log record, it is deemed desirable to place a warning sign at control switch handles, on face of truck switches, in front of oil circuit breaker or disconnect switch compartments, on potential transformer fuses, or at any location where hand or electrical operation may energize the circuit from any source. (See N E S C, Rule 421F.)

Signs or tags may be of different colors to designate various meanings. The original practice of using one red card to signify absolute holdoff is rendered more or less ineffectual on some systems by the necessity of applying test voltages of wide range in values, limited trial operations, etc., in themselves carrying hazards which must be flagged, and which may be performed by others than the regular operators. Such tests must be performed while full system voltages are still held off. Thus modification in meanings of holdoff tags sometimes becomes necessary.

To provide modified meanings some companies use a multicolored series of signs, each color corresponding to a limited significance, such as:

a. Red Holdoff Sign—Holdoff absolute and inviolable.
b. Blue Holdoff Sign—Holdoff except test voltage below 150 v.
c. Yellow Holdoff Sign—Holdoff except high voltage tests.
d. Green Holdoff Sign—Holdoff except for limited operation.

2. *Attachment Clips.* It is suggested that substantial holdoff clips be furnished so as to insure the attachment of signs. Clips may be easily designed also to act as stops preventing the throwing of control switch handle while signs are attached.

3. *Locks and Blocks.* Although signs have been placed on control switch handles, the closing of an oil circuit breaker should be further prevented by a mechanical block placed in its closing mechanism and this block locked in position. Foreman protected or his representative should see this lock and block placed.

Danger of hand operation of normally remote controlled oil circuit breakers may be obviated by placing a red baffle plug in hand lever receptacle as a warning.

4. *Grounds.* Before issuing holdoff a usually necessary precaution is the shorting and grounding of circuit protected. Report on details and methods of grounding for protection has been issued by Accident Prevention Committee in its report entitled "Temporary Safety Grounding" (N E L A Publication No. 278-4), and is therefore excluded here.

Foreman, when checking the locking and blocking of oil circuit breaker, should also examine ground to assure himself that he is protected.

Protection grounds at generating or substations are generally placed by or at direction of person issuing holdoff; at remote points, by person doing the work.

It is suggested that mechanical means of placing grounds, controlled from a safe distance, is desirable. For examples, see "Temporary Safety Grounding," N E L A Publication No. 278-4.

5. *Warning Placards.* Holdoff signs placed on control boards are for the purpose of informing operators that they may not apply system voltage; that is, a red sign is used to indicate danger to his perception. In addition to this warning to operator and on the contrary, it may be found desirable to give the workmen protected an indication of *safety,* instead of danger. (See N E S C Rules 411 I and 420F.)

Do Not Confuse "Placard" with Holdoff "Sign" or "Tag"

The practice of hanging red "danger" placards to indicate the boundaries of safe working spaces has in some companies been supplemented by practice of hanging green "safety" placards on the circuits actually protected. No operator or foreman is liable to hang a "safety" placard until he has assured himself he is correct, since his responsibility for such action is much more definite. An unmarked circuit is then considered alive until checked and marked "safe," which affords a much more positive screen of the danger points. A foreman may be observed by his men placing the "safety" placard and handling the circuit before they, the workmen, are required to handle it.

6. *Series Locks.* In addition to simple locks, some systems make very effective use of locks in series, the key to each being released by a necessary prior step which renders the succeeding step safe. Only the correct sequence of operations will release the final key admitting access to the location of circuit or apparatus to be worked on under protection. An example is the Cory system.

7. *Automatic Barriers.* Certain classes of employes not thoroughly acquainted with the hazards of electrical op-

eration, such as painters, plumbers, carpenters, laborers and even unqualified electrical workers and helpers, should be physically prevented from entering operating galleries, vaults, etc., unless accompanied by an authorized person. The use of locked doors and gates is desirable. The issue of keys may be limited to qualified foremen and supervision and policing of access thereby made possible.

Thoroughly responsible and competent employes need not be surrounded by a multiplicity of protection interlocks which tends to confuse and may be complicated but not infallible. However, for such operations as application of kenotron d-c test voltages, the railing or inclosures of the test sets may very properly and wisely be so interlocked as an auxiliary to holdoff, that the inclosure may not be entered while test is on or until capacity charge of tested apparatus has been dissipated. Since the gradual dissipation of charge and stress in dielectric requires a considerable period, depending on the quality of the insulation, a time lock might be suggested for consideration, to hold until ground had been applied for a desirable duration of 15 min after test.

V. Adaptation

To adapt the features of the multicolor holdoff signs to existing systems depends on the local features of design and division of responsibilities. However, since the outline covers principles rather than details of method, it is believed to be applicable to the majority of companies with little difficulty or disturbance to routine. The various features are in actual operation and have received the consideration and approval of a number of representatives of companies, large and small, and with varied conditions to be met.

VI. Competent Persons

There should be on file with System Operators lists of persons competent to direct construction and test opera-

tions, and receive protection holdoff. However, System Operators should not be charged with responsibility of checking to see that only competent persons receive holdoff signs. This should be a function of those directing the work of persons requesting protection.

When shifts are changed, succeeding foremen should receive their own holdoffs. However, in rare cases in extended operations involving little change of conditions, it may prove desirable for a general foreman or supervisor to receive holdoff under which two or more shift foremen may work without changing holdoffs. This should be a matter of individual company rule.

VII. Selection of Apparatus for Holdoff

The foreman responsible for a gang working in an operating station has a heavy responsibility which cannot be delegated or avoided, in the selection of apparatus to be held out to protect circuits on which his men are to work. He must possess thorough knowledge of all circuits, the possibility of back-feed, the physical location and clearances of parts to be isolated from energized parts, and means of insuring protection. While his is the primary responsibility, he should have his plans checked by his superior before requesting the protection by the System Operator. Many companies provide for this, except in emergency, by the requirement that advance written request be made to Operating Department. In the preparation of summary sheet of these requests is afforded an opportunity to check the provisions for adequacy and correctness.

The System Operator affords final check but should not be required to check all minor details of protection, since such necessity would congest his desk and the check would be necessarily hurried. Emergency provisions should require careful detailed study by System Operator, since emergency requirements are necessarily drawn up with some degree of haste in the field.

VIII. Communication

While the telephone is the mainstay, consideration is recommended of the telautograph, telegraph typewriter, radio, etc. Messages by any such means of communication should receive careful check at each end.

Section V

TEST PROVISIONS—PROTECTIVE GROUNDS

Electrical equipment should have periodic adjustment and test. For this reason the time consumed in making repeated temporary test connections will warrant installation of test links. However, even if more expensive, safety to life and property warrants thoroughgoing provision for tests to obviate necessity of temporary wiring. Some test provisions are:

I. Generating Stations

Ground and test switches are automatically remote controlled and interlocked so they may not be closed unless system voltage has been removed from circuit. Meter and instrument test links are in fairly general use.

II. Sub-Stations

Test taps are arranged so test cables may be applied by men located safely with respect to live circuits.

III. Protective Grounds

This subject has been covered by the Accident Prevention Committee Serial Report, "Temporary Safety Grounding" (N E L A Publication No. 278-4), and attention is directed to the recommendations of that report.

Frequently ground and test provisions are combined in one piece of auxiliary equipment. Illustrations of this are contained in "Temporary Safety Grounding," N E L A Publication No. 278-4. (See N E S C, Rule 163.)

Section VI

ADOPTION, EDUCATION, ENFORCEMENT

From the close study made by the Accident Prevention Committee of effective accident prevention work, it has been found that the best results follow the adoption of safety working rules and methods, education of employes regarding these rules and strict rule enforcement by officials of the company.

For any company wishing to review its processes the committee recommends the following procedure:

I. Authority

Establishment of a central authority reporting to the executive. While this authority should have power to enforce orders if necessary, the person exerting it should be chosen for his ability to think straight and his tact in selling rather than imposing his ideas. He should be an engineer.

II. Central Committee

Under the Safety Director there should be a corps of inspectors reporting to him. The inspectors and also representatives of each department, including those having purely office functions, should form a central committee, meeting regularly for inspirational talks and demonstrations of resuscitation, first aid (necessary features only, such as tourniquet application, etc.) and safety methods.

The departmental representatives should organize their own groups for creating right spirit among employes, educational work, etc.

The departmental representatives or inspectors should report to Department Head, who should be held responsible, regardless of activities of Safety Director, for the safety condition and accident results in his department.

III. General Roll

All employes should receive inspirational information and instruction. The success depends more on their cooperation than on rules.

IV. Safety Instructions

Every operating system has its own peculiar characteristics of design. For this reason the Safety Director should review all operating and construction practices and prepare an instruction book to be used as a text in safety education and the guidance of all employes.

V. Holdoff System

An especially important feature of the system practice is the holdoff system. This should be subject of specially detailed instruction in its application to the system, with its accessories of locks, blocks and protective grounds. (See Section IV, Holdoffs.)

VI. Contractors' Employes

Contractors and their employes should be subject to same safety rules as company employes. Provision for this should be made in contracts, with an enforcement penalty of severe nature. It is not enough for a contractor to buy insurance and then fail entirely to guard his men.

VII. Setting Up Safety Organization

Reference on this subject is made to Accident Prevention Committee serial 267-94 report, "How to Set Up an Accident Prevention Organization" (N E L A Publication No. 267-94).

PART B—GENERAL CONSTRUCTION PRACTICE

Section VII

GENERAL

I. Safety Responsibility

Superintendents and foremen must recognize their responsibility in accident prevention. They are responsible for the general administration of all work, and it is their duty to have accident hazards reduced to a minimum.

Frequent inspections and thorough safety instructions to all men under their supervision are their distinct duties and should always be required by managements

Workmen, likewise, are expected to familiarize themselves with the hazards peculiar to their work, and perform all their tasks with due regard to safety as their portion of the responsibility.

Section VIII

HOUSEKEEPING

Neat, orderly construction jobs are of such vital importance to accident prevention that frequent repetition of the more general precautions is necessary.

Workmen are most frequently injured by falling objects, or because they trip, stumble, slip, or step on an object in their pathway. Often there is a tendency on the part of investigators to obscure the real cause of this type of accident, and attribute it to carelessness or some other vague cause.

All tools should be handled carefully and held securely to prevent them falling on or striking other workmen. Hand tools carelessly laid about form tripping or stumbling hazards, when a tool house or boxes would provide convenient and adequate storage.

Adequate toe-boards will prevent material piled near the edge of an elevated structure, or opening, from dropping on workmen below. Even comparatively light arti-

cles may inflict severe injuries when falling from an appreciable height. Toe-boards are also useful in confining piles of sand, gravel, and other loose materials.

Accidents on stairs, stair landings, and fire-escapes are often more serious than on level floors. Therefore it is very important that these places be kept clear of obstructions. This is not only a safety precaution, but in many communities is a fire regulation. Very frequently serious accidents result from falls in such places occasioned by stepping on nails, pencils, or other small objects.

Puddles and drippings of oil or water make floors slippery and are a distinct hazard. Such conditions should be eliminated, and the areas covered with sand or sawdust. Sharp objects should be kept clear of all walkways and places where they can be stepped on.

Stored material should be arranged in stable stacks to prevent overturning or other movement likely to cause injury. Stability can be gained through attention to the dimensions of stacks, and by the use of binder strips. Special attention should be given to clearance between sprinkler systems and the top of material stored indoors.

If lumber is to be re-used, the nails should be removed. Otherwise it should be moved from working spaces and disposed of. Scrap bins should be provided for broken glass, sheet metal scraps, and other waste material.

Material should be loaded carefully on trucks and wheelbarrows to prevent falling off or overturning. These conveyances should never be overloaded. Loads projecting over the side of trucks should be carefully watched in transit. The types of trucks must be selected for their service.

Despite all precautions, accidents must be expected and prepared for. Every project on which the number of men or nature of the work warrants it should be provided with an emergency hospital. Smaller projects should have first aid men, and some arrangements with a nearby doctor, for treating minor injuries. The "First

Aid Manual" compiled and made available by the National Electric Light Association contains much valuable information.

Gas poisoning, electric shock, and drowning are three common and serious hazards in construction. Besides taking precautions against these, the proper treatment of victims should be general knowledge. Prone pressure resuscitation has been generally accepted as the best treatment. Posters showing how the treatment is correctly administered are available through the National Electric Light Association, and a comprehensive pamphlet* giving the procedure in detail has been published jointly by the American Gas Association and the National Electric Light Association. This is titled "Resuscitation in Gas Poisoning, Electric Shock, and Drowning" (N E L A Publication No. 289-70).

Good housekeeping is as much the problem of the management as of the employe. It cannot be secured simply by attempting to enforce rules. It is important to have clean-up jobs definitely assigned. Generally, old employes can be used for this work and are easily impressed with its importance in preventing accidents and fires.

Wash rooms and lockers are a housekeeping necessity. When adequate lockers are not provided, old clothing accumulates and presents a constant fire hazard. Clean-up men hesitate to destroy old clothing, although it may apparently have no owner.

Every effort should be made to assist the worker in keeping the job clean and orderly. Unfortunately, some employers have not recognized the economy of providing lockers, making provisions for refuse disposal and other such "luxuries." Aside from promoting good housekeeping and reducing accidents and fire hazards, these aids show interest by the management and have a direct bearing on the spirit and efficiency of workmen.

*Text of pamphlet is reprinted as an appendix to this handbook

Section IX
FIRE PROTECTION

The nearest fire-alarm boxes and fire plugs should be located, and the fire department's telephone number posted. The location of main line electric switches and gas valves should be noted. Gas should be turned off, on the company's premises, as soon as fire is discovered.

Carbon dioxide fire extinguishers are especially adapted to use in closed places where the gas can be confined. This apparatus is very effective and may be used without the damage caused by water and chemicals used in most extinguishers. It is particularly suited to fighting fires in switchboard wiring and other electrical equipment.

Fire extinguishers should be placed around the job, taking note of their characteristics as given in Table II.

Section X
EXPLOSIVES

I. Handling

All contact with explosives should be kept from employes, except those specifically authorized to handle them. Explosives are dangerous at all times, and are not to be treated like other construction supplies. They should never be left unattended; nor be handled, stored, or transported with any other material. Always comply with local regulations on explosives.

Open boxes carefully, using wooden wedges and wooden mallet when they are nailed. A screwdriver is necessary for screwed covers. Handling dynamite with bare hands often causes headaches. Use gloves, and destroy them before they become damp and sticky. Cartridges showing glycerine crystals on the outside should not be used.

Dynamite freezes at the high temperature of 50 F, and should not then be cut or broken until it is thawed.

Table II—Characte

TYPE			PAILS; PAILS IN TANKS	SODA
CHEMICALS OR LIQUIDS EMPLOYED			Water Pails, Water Foam pails Aluminum sulphate —bicarbonate of soda with foaming agent	Bicarbon sulph
METHOD OF OPERATING			Throw contents	I
METHOD BY WHICH PRESSURE IS CREATED				Chemic
EFFECTIVE RANGE OF STREAM			10 to 15 feet	30 t
RATED LIQUID CAPACITY OF COMMON SIZES			10, 13 and 14 quarts	2½, 1½
NATURE OF PRINCIPAL EXTINGUISHING AGENT			Water pail liquid Foam pail foam, mass of bubbles filled with carbon dioxide gas	Liquid a
PRINCIPAL EXTINGUISHING EFFECT			Water pail cooling Foam pail blanketing	C
IS IT RECOGNIZED AS ADAPTED FOR USE ON	Class A Fires	Wood, Textiles, Rubbish, Etc.	YES Fires in such materials can generally be extinguished by cooling or quenching effect of water or by smothering or blanketing effect of foam	Fires in s can gene tinguished or quench water
	Class B Fires	Oils, Greases, Paints, Etc.	Water pails NO Foam pails: YES Blanketing effect essential	Blanketin generally
	Class C Fires	Electrical Equipment or Apparatus	NO Extinguishing agent conducts electricity	Extinguis conducts
SHOULD IT BE PROTECTED FROM FREEZING?			YES	
UNDERWRITERS' CLASSIFICATION. Letters indicate class of fire as above; figures indicate number of devices per unit of protection			Water pails: A-5 Water pails in tank: A-1 Foam pails, A-5, B-5	2½ 1½ 1¼

CALCIUM CHLORIDE SOLUTIONS FOR WATER PAILS AND HAND PUMP EXTIN
2½ Gallons Anti Freezing Solution

Freezing temperature	Water	Calcium Chloride	Specific Gravity
10° F	2 gals 1 qt	5 lbs	1 139
Zero F	2 gals 1 qt	6¼ lbs.	1 175
10° below zero F	2 gals.	7 lbs 6 oz	1 205
20° below zero F	2 gals	8 lbs. 6 oz.	1 228
30° below zero F	2 gals	9 lbs. 2 oz.	1 246
40° below zero F	2 gals	10 lbs.	1 263

ristics of

AND ACID

ate of soda,
uric acid

nvert

al reaction

o 40 feet

and 1¼ gals

oda solution

ooling

YES
uch material
rally be ex-
by cooling
ing effect of

NO
g effect not
produced

NO
hing agent
electricity

YES

gal. A-1
gal A-2
gal A-2

GUISHERS

Degrees Baume

17 7
21 6
24 7
26 9
28.6
30.2

Hand Fire Extinguishers.

FOAM	SPECIAL TETRACHLORIDE	HAND PUMP	SPE ANTI-F
Aluminum sulphate, bicarbonate of soda with foaming agent	Specially prepared carbon tetrachloride with important components for lowering freezing point	Water. For freezing temperatures use special grade calcium chloride free from corrosive elements	Special gr chloride corrosive Safety fu
Invert	Pump	Pump	Ih
Chemical reaction	Fumping action	Pumping action	Burning of
30 to 40 feet	20 feet or more under full pump pressure	20 to 30 feet	30 to
2½ gallons	1 and 1½ quar s	2½ and 5 gallons	2½
Foam, mass of bubbles filled with carbon dioxide gas	Free gas produced when liquid is vaporized by fire	Liquid, calcium chloride solution	Liquid, cal ide s
Blanketing	Blanketing	Cooling	Coo
YES Blanketing action generally effective in such fires	NO Other types better adapted for use on Class A fires	YES Fires in such material can generally be extinguished by cooling or quenching effect of water	Y Fires in su can gener tinguished or quenchi water
YES Blanketing effect of foam produced effectively excludes oxygen from fire	YES Blanketing effect of gas formed when liquid strikes fire excludes oxygen	NO Blanketing effect not generally produced	N Blanketing generally
NO Extinguishing agent conducts electricity	YES Liquid is practically a non-conductor of electricity	NO Extinguishing agent conducts electricity	N Extinguish conducts e
YES	NO	YES Unless calcium chloride solution is used	N
A-1, B-1	1 quart, 1½ quart; B-2, C-2	5 gal A-1 2½ gal. A-2	A

Reprint from an article by C. R. D'Olive, formerly Superintendent of Label Service, Underwriters' Laboratories, in NATIONAL SAFETY NEWS, published by the National Safety Council, 108 East Ohio Street, Chicago.

In thawing dynamite, place it in a container that is in turn placed in warm water—not warmer than the hand can stand. It is dangerous to thaw near steam pipes, in an oven, or in bright sunlight.

A case knife is safer than a folding knife for cutting, because the former has no hinge to catch the explosive and later cause an accident.

II. Transportation

Always comply with state and local regulations governing the transportation of dynamite, high explosives and detonators. It is desirable when practicable that detonators and high explosives or dynamite be hauled on separate conveyances.

Very small shocks are likely to explode detonators, and extreme care must be used in packing them for transportation. Special cases should be used for this purpose, which are constructed to prevent shock.

Powder men should not carry blasting caps in their pockets, nor should caps and explosives be carried at the same time. Make two trips, or use two men.

III. Storage

Keep the storeroom clean, and allow no smoking or open flames, such as lanterns, within or in its vicinity. Low pressure steam or hot water heat is the safest. Keep the storeroom cool and dry, and well protected from fire, lightning, and theft.

Store blasting caps in a place separate from the explosives and in waterproof containers.

IV. Blasting

Tamp charges with a wooden bar, using pressure, not blows. Electric blasting caps are preferable to fuse caps. Do not use electric detonators during thunderstorms; should the charge be primed, keep everyone away until the storm is over, and disconnect the lead wires to the exploder.

Give warning and see that everyone is clear before

exploding a charge. Blast the minimum number of holes at a time, and in confined locations place a mattress over the charge. Do not immediately reload an exploded hole; it may be hot and explode the second charge prematurely.

V. Unexploded Charges

Wait at least 1 hr before examining an unexploded charge. Do not attempt to drill or pick out an unexploded charge. It is much safer to plant another 2 ft away.

VI. Waste Disposal

Never burn boxes that have had explosives in them in stoves or boilers, but always in the open and clear of all objects.

Do not return explosives left over on any job to stock, but dispose of them by burning. Any remainder of blasting caps should be discharged under about 2 ft of ground.

Section XI

GASES AND LIQUIDS

I. Classification of Liquids and Gases

Many gases form highly explosive mixtures with air. Others are flammable and may inflict severe burns. The following classification includes the most commonly used explosives and flammable liquids and gases:

Some Explosive and Poisonous Gases

Acetylene	Methane
Carbon Monoxide	Natural Gas
Hydrogen	Nitrogen Peroxide
Hydrogen Sulphide	Sulphur Dioxide
Manufactured Gas	

Some Flammable Liquids

Alcohol	Many Cleaning Solutions
Benzol	Naphtha
Dryers	Paints
Ether	Petroleum
Fuel Oil	Polishing Solutions
Gasoline	Turpentine
Kerosene	Varnishes

II. Storing

Exercise great care in storing flammable liquids and gases. Liquids are best stored in underground tanks, or in safety cans bearing Underwriter's label. Metal racks should be provided for can storage.

The storehouse should be a separate, detached, fire-resisting building. Ventilation and cleanliness are essential. Do not allow oily rags, dust, or rubbish to accumulate. Neither open lights nor smoking should be permitted in or near the oil house.

III. Handling

When pouring flammable liquids, keep containers and funnels in contact with each other or joined by a chain. Static sparks from ungrounded machinery may ignite flammable vapors and gases. Handle these gases and liquids with care, keeping them from high temperatures. Overheated bearings or friction of belts can ignite flammable gases, as can sunshine through window glass, bottles, and the like, when acting as a lens.

Take care not to inhale vapors and gases; many of them are injurious. Never allow flammable vapors or gases to mix with air, especially in a closed space. They form highly explosive mixtures which are very easily ignited by sparks, flames, or excessive heat.

Section XII

STORING MATERIAL

I. Indoors

Flammable materials should be stored in a fire-resisting building. Sand, gravel, bricks, cement, and other heavy materials require a floor of unusual strength. Whether indoors or outdoors, all material should be piled or stacked in an orderly manner. The foreman in charge of storage should be responsible for safety.

Cement, lime, and similar material should not be stacked more than ten bags high, except in specially con-

structed bins. The first four end bags should be cross-piled in two tiers to the fifth bag, where a step-back of one bag should be made. Above the fifth bag make one cross tier. The back tier, when not resting against a supporting wall, should be stepped back one bag in every five. Bags in the outer tier should have mouths facing in.

Sand, gravel, and crushed stone should be stored in well-braced bins, with substantial partitions. Men should never work under the overhang of piled materials. This is especially true when the material is frozen.

II. Outdoors

Do not allow loitering, loafing, or playing on or around piles of material. All stacks or piles of material should be protected against upsetting by trucks and trains.

Lumber should be stacked on a solid foundation, with sills to keep it off the ground and provide a level foundation. Cross piling should be used where stacks are more than 4 ft high.

Brick and tile should be stacked on planks and never on soft ground. Except in properly constructed bins, they should never be stacked over 7 ft high. Above 4 ft, taper back 1 in. per layer. Tie-strips should be used in stacking material of this nature.

Poles, pipe, piling, and other material which cannot readily be formed into stable stacks should be carefully braced or stored in a suitable rack.

Section XIII

USE OF HAND TOOLS

I. Storage

Tool rooms should be provided on every job, with a man in charge responsible for inspection and repair. Defective tools should never be issued nor kept on a job. They should be either repaired or discarded.

II. Material Handling Tools

Shovels, picks, digging bars, and the like should be carefully stored, and on the job laid so as not to create a stumbing hazard. They may inflict a serious wound.

Wood hooks, cant hooks, or peavies are safest when kept sharp and in good repair. They also form stumbling hazards when laid carelessly about.

III. Cutting and Abrasion Tools

Cutting tools should be kept sharp. A draw-knife should never be used with the knee bracing the work. Wood chisels, axes, and the like should be handled carefully and not laid indiscriminately about.

Pliers, bolt cutters, shears, and similar tools should be used for what they were designed, and not as utility tools. When cutting members under tension, or spring wire in coils, stand clear of both ends. Warn other workmen within range of recoil.

Files should be equipped with handles. Whenever filing work in a machine, the operator should wear short sleeves. Goggles may also be needed to protect the eyes.

IV. Hammers, Prying Tools

Hammers and similar tools must be fastened securely on their handles. Where practical, use hammers with knurled faces.

Wrenches should not be used as hammers. Place monkey wrenches on nuts with the jaw opening facing in the direction the handle is to move.

Dull or broken-end crowbars are a hazard. When prying, care should be exercised that the bar does not slip. Serious falls frequently result from this cause.

V. Pneumatic Tools

Only pneumatic tools in good working condition should be used. Tools or hose showing defects should be immediately withdrawn from service and repaired. Hammers should be equipped with safety tool retainers.

None but men familiar with pneumatic tools should be

permitted to use them. Pointing hammers or air hose at a person should be positively forbidden. Compressed air should not be used to remove dust from the clothing while it is worn.

VI. Jacks

Worm, ratchet, or hydraulic jacks should be used only for lifting or pushing—the purpose for which they were designed. Jacks should not be overloaded, nor screw or rack shaft extended beyond its safe limit.

See that jacks are of sufficient capacity, well centered under the load, and are resting on a solid foundation. When using screw jacks, workmen should be careful that bar does not slip and throw them. A pawl that will not fully and properly engage in the ratchet is dangerous.

When it is necessary to maintain a load which has been jacked into position, it should be blocked up to relieve the strain on the jacks. Unless absolutely necessary, no one should go under a load supported by jacks. See that hands and feet are clear before jacks are released.

Section XIV

TRUCKING AND HAULING

I. Roads

A construction job usually has poor or at least temporary roads. Such roads generally have a poor foundation, although the surface may be good. Temporary roads are treacherous for transporting heavy loads, and extreme caution should be used at all times.

II. Laws and Ordinances

Supply each driver with a copy of the motor vehicle ordinance. Traffic laws must be obeyed. Specified load limits on roads and bridges should never be exceeded without proper authority. Remember, public opinion can be greatly influenced by the actions of truck drivers. Courtesy, as well as safety, should be demanded of every driver.

III. Mechanical Condition of Trucks

Good mechanical condition of trucks is absolutely essential to their proper operation. Responsibility for the condition of the truck rests upon the operator. He should report any breakage or mechanical failure, and as repairs are made, take responsibility for keeping the truck in condition. Do not use a truck that cannot be controlled under all circumstances.

IV. Handling Trucks

Truck operators must be safe as well as efficient. Motors should be cranked only by operators. Self-starters are preferable. The first rule of trucking is that only the driver and his helpers be allowed to ride. Helpers should ride inside, not on the running boards, fenders, or edges of trucks.

Trucks should be parked with the front wheels toward the curb, or otherwise securely blocked, with the emergency brake set. The ignition should be switched off and, in the case of electric trucks, the running key should be removed.

The use of loaded trucks for passenger transportation is dangerous and should be prohibited. Truck tail-gates should be securely fastened when hauling passengers.

V. Loading

Trucks should be loaded equally on each side, and with due consideration to capacity. Shifting loads often cause failure of such parts as springs and axles, or may cause a truck to overturn. Temporary roads produce abnormal strain on trucks and greatly increase the tendency of loads to shift.

Specially constructed trucks and trailers should be used in transporting heavy and awkward equipment, such as transformers, poles, heavy machinery, and the like.

VI. Rolling and Skidding

When rolling or skidding heavy equipment, a winch is the best source of power. This reduces the number

Fig. 6—Proper Method of Hauling a Heavy Load.

of men exposed to the hazard, and provides a steady, controlled pull. Experienced men should be used in handling heavy equipment. Care is necessary that ropes or cables are not overstrained with a power winch.

Section XV

TEMPORARY RAILROADS

I. Tracks

Temporary tracks should be constructed on a solid roadbed, and sufficiently ballasted to insure safe operation of trains. Place switch stands at ample distances from tracks to clear trainmen. Railroad gates should allow generous clearance; otherwise conspicuous warnings must be posted. Switch levers should throw parallel to the tracks.

Frogs, switches, and guard rails should be properly guarded by blocking. Road crossings should be properly planked. Avoid crossing railroad tracks with roadways and walks as much as possible. Gates for pedes-

trians should be separate from railroad and vehicle traffic gates. Doorways opening directly onto railroad tracks should be properly guarded.

Substantial bumper posts should be placed at the ends of all stub tracks. A car blocker must be used when cars are left standing on a grade. Derailers should be installed on all grade sidings.

II. Switching Cars

Use only experienced trainmen for switching cars. In riding cars, men should use extreme care and watch for clearance warnings. Cars should not be "kicked" across unguarded roadways or walks. Never use an ordinary crowbar to move cars; use a car mover.

III. Loading and Unloading Cars

When loading material or equipment, brace securely. Follow standard car bracing specifications when practical. Do not dump material into a car from a great height. Never dump miscellaneous scrap from higher than the edge of the car.

Keep clear while removing tie-wires from car side stakes. Safety wrenches should be used for opening drop-bottom cars. Where gangplanks are used between cars and platform, ground, or material pile, they should be securely anchored to prevent slipping.

Section XVJ
WRECKING

I. Preparation before Wrecking

First shut off from the building all water, gas, and electricity, and remove all windows, fixtures, and glass partitions.

II. Equipment

Erect self-supporting staging, if necessary, and demolish the building part by part. Use enclosed chutes, with baffles if run exceeds two floors, and heavy-weighted

canvas at the mouth to prevent material from bounding out of trucks.

Screens will confine flying material to restricted areas, and water will lessen the dust from plaster and brickwork.

III. Handling Material

Except in isolated buildings, never allow walls or chimneys to fall as a whole. Do not leave them so that wind, built-in beams, or other forces may overturn them. Avoid removing members that support parts of the building still standing. Timbers and steel beams should be secured before cutting. All heavy or bulky material should be lowered, not dropped.

Guard against material accumulating and overloading the floors below the wrecking level. Have no unnecessary work going on beneath wrecking operations.

Section XVII

EXCAVATION

I. Adjacent Structures

Brace adjacent building walls to prevent settling, and see that sills of shores are on solid ground. Particular care should be exercised that sills are not placed on frozen ground. Prevent rain and water from undermining foundations. Sidewalks and roadways must be firmly supported.

II. Site

Remove any rocks, trees, and the like which might fall into the pit. Exercise care in operating trucks or placing heavy machinery near the edge of pits.

Open excavations on streets or thoroughfares should be protected by earth barriers or railings bearing red flags during the daytime and warning lights at night. When closing an opening temporarily, the strength of the flooring should be carefully considered.

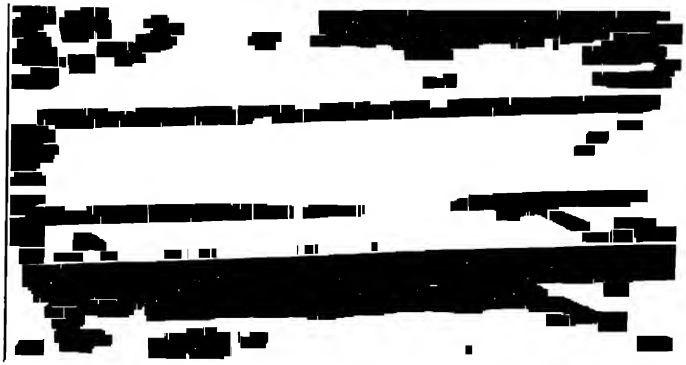


Fig 7—Street Opening Properly Barricaded and Planked

III. Steam Shovel

Set the steam shovel on heavy planks and keep away from the dipper when in motion. Protect walls, shoring, and scaffolds from the shovel. Electric power cables must be well insulated and protected from workmen and teams.

IV. Ramps

Ramps should be firm, protected from slides and undercutting, and cross-boarded on the surface. When trucks are being hauled out of the pit, workmen should keep clear of the cables.

Section XVIII
TUNNELS

I. Working Conditions

Every precaution must be taken to ventilate the tunnel continuously and thoroughly, especially when the work is done under air pressure. Good lighting is a safeguard of vital importance. A doctor should approve each workman before he is employed for jobs under air pressure.

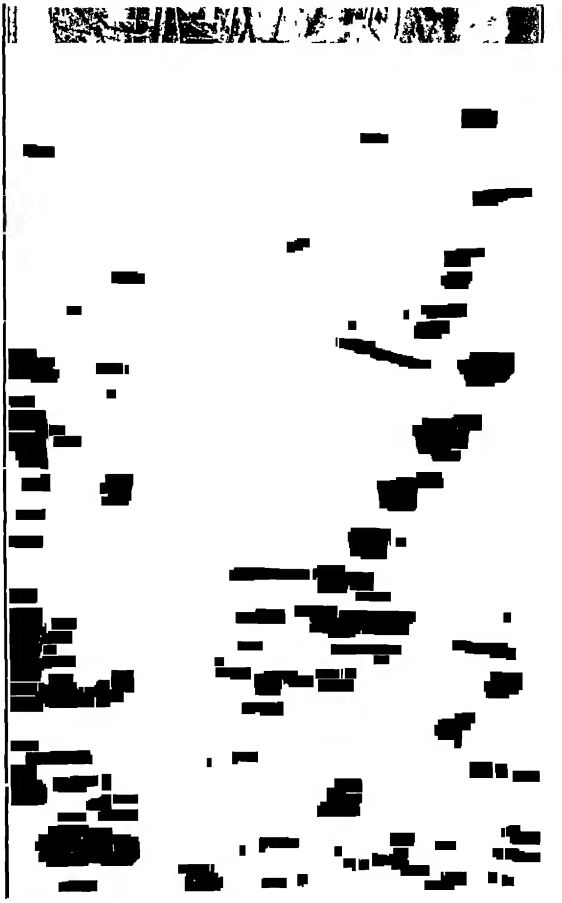


Fig 8—Steel Bracing Adapted to a Large Excavation

II. Tunneling

Tunnel lagging must be thoroughly braced to prevent buckling. Roofs should be frequently tested for loose earth and boulders. Always drill at least 20 ft in advance of heading when driving toward water. A good practice is to follow excavating with permanent masonry as soon as possible. Rubbish and combustibles should be removed as soon as they collect.

Section XIX

HOISTS AND ELEVATORS

I. Towers

Build towers of sound material and ample strength; bolt important members. Well-anchored guys should be installed as the tower is erected; do not guy to fresh concrete or other insecure parts. Base of tower should be screened or boarded on as many sides as possible, and screening should run to entire height on sides close to other buildings. A caged-in ladder should run up the tower.

Table III gives the safe loads in tons on yellow pine timber used as column, post, or brace in falsework.

TABLE III

Safe Loads in Tons on Yellow Pine Timber Used as Column, Post or Brace in Falsework

Size in	Max. Length in Ft	Safe Loads Tons
4 x 4	10	3
6 x 6	20	7
8 x 8	32	13
10 x 10	40	20
12 x 12	50	30
14 x 14	60	40

NOTE: The above table is based on an allowable unit crushing stress of 400 lb per sq in. in timber sill on which post stands.—McClintic-Marshall Co

II. Hoist Engine

The hoist engine should have a pawl to hold suspended loads; the brakes should not be depended upon for this purpose. Keep oil off the brake drums. Avoid sudden starts and stops.

Note: In this connection the General Electric Company has developed a device which they term "Thrustor", which may be used in connection with a hoist brake to ease the shock of stopping. This device is fully described in General Electric Pamphlet No. GEA-1262-A.

Notify the engineer before any work is done around any of the hoist equipment. Protect the engineer from falling material by 2-inch roof planks. Pipe exhaust steam to a point where it will not interfere with his view.

Signal whistles are dangerous; they may be confused with other noises; hand signals or bells are better. Mark the cable to indicate the position of the hoist at each landing.

Fig. 9—Adequately Protected Concrete Hoist.

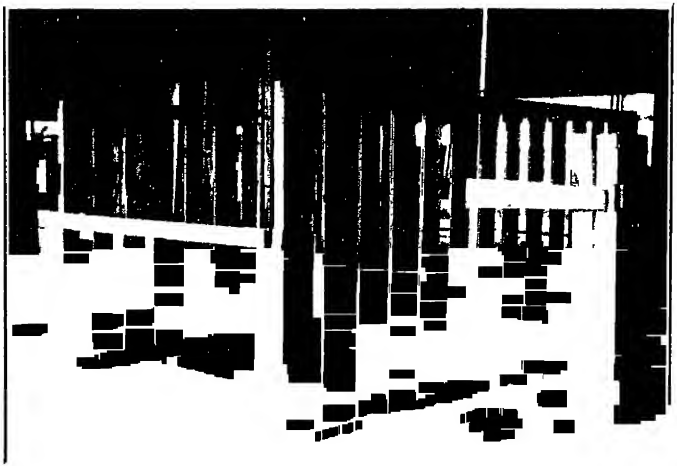


Fig 10—A Safe Method of Barricading Elevator Openings

III. Construction Elevator Platforms

No one should ride on elevators or hoists. Platforms must be large enough so wheelbarrows do not project over the edge. The floor should have stop cleats for wheelbarrows and toe-boards on unused sides.

IV. Pits

Precautions should be taken to keep workmen from underneath the elevator, especially when it runs to the basement.

On bucket hoists the pit should be well drained and arranged so that any spill will fall below the blocking in which the bucket rests. Never allow workmen in the pit without first resting the bucket in timbers placed across the opening.

Section XX
DERRICKS

I. Safe Loads

See that derrick is strong enough for loads, and that

it is securely anchored and braced on solid foundation.

Table IV gives safe loads in tons on yellow pine timber used as a boom.

TABLE IV

Safe Loads in Tons on Yellow Pine Timber Used as a Boom

a. With 17-ft masts

Timber Size			Radius in Ft								
In.	In.	Ft.	10	15	20	25	30	35	40	45	50
6 x	6 x	20.....	5	5	5	..	..	..	..	..	.
6 x	6 x	30.....	2	2	2	1	1	..	..	..	..
8 x	8 x	20.....	10	10	10	.	..	.	..	..	.
8 x	8 x	30.....	6	6	6	6	5	..	..	.	..
8 x	8 x	40.....	3	3	2	2	1	..	..	..	..

b. With 30-ft mast

8 x	8 x	30...	11	11	11	11	10	..	..	..	..
8 x	8 x	40.....	7	6	5	4	2	1	..	..	..
10 x	10 x	30.....	21	21	21	21	21	..	.	..	..
10 x	10 x	40.....	14	14	14	13	11	9	8	..	..
10 x	10 x	50...	9	8	6	5	3	1	..	..	..

c. With 40-ft mast

10 x	10 x	40..	17	17	17	16	14	12	10	..	.
10 x	10 x	50..... ...	11	10	8	6	4	2	..	..	..
12 x	12 x	40	28	28	28	28	28	26	24	.	..
12 x	12 x	50.....	20	20	20	17	15	12	10	7	5
12 x	12 x	60..... ...	14	13	10	7	5	2	..	..	.
14 x	14 x	40.....	42	42	42	42	42	42	41	..	.
14 x	14 x	50.....	31	31	31	31	29	26	23	20	17
14 x	14 x	60.....	23	23	22	19	16	13	10	7	3

NOTE: The above table is based on a unit stress of $1000-10\frac{L}{D}$ for compression, and of $1500-15\frac{L}{D}$ for combined stress (compression, and bending) where L=length in inches and D=width in inches. Table (a) is figured on the use of a single load line, and (b) and (c) on a two-part load line, although the number of parts would depend on the load, and on the strength of the line used.

With a mast shorter than specified the stresses in boom will be increased.—McClintic-Marshall Co.

II. Mast and Boom

The mast needs at least six guy wires secured to the top guy plates with shackles. When work stops for any length of time, lower boom to horizontal or raise to vertical to prevent swinging in the wind or being tampered with.

Special care should be taken if boom is longer than mast, and in vertical position, to avoid pulling off top goose-neck or spider. Do not depend on cotter pins to hold the goose-neck or spider in place, but see that strong holding down guys are installed. On stiff-leg derricks always use double sets of bolts to fasten back the legs, and enclose the weights in well-constructed boxes.

III. Loads

Use a shackle instead of a hoisting hook with swinging buckets. The bucket may strike an obstruction and be lifted off an ordinary hook. Always keep hooks closed. A hold-back line or guide rope should be used on all loads that are liable to swing. Do not allow workmen to ride on loads handled by derricks or on slings, nor to stand under a load suspended on a derrick or other material handling rig.

IV. Hand Cranks

When not in use, or when loads are being lowered, remove hand cranks to prevent their striking someone. When lowering by hand, be careful that they do not slip off.

Section XXI
RIGGING

I. Requirements of Riggers

The art of rigging is acquired only by long schooling and experience. Every man on this work should be required to demonstrate that he is qualified by experience and training. No man who is subject to dizziness, heart attacks, or who has suffered skull fracture should be employed as a rigger. Physical fitness should be a primary requirement for this work.

Many workmen and engineers think, because the work looks easy, anyone can do rigging. Rigging in the hands of inexperienced men proves hazardous both to themselves and fellow workmen, and should never be permitted. Riggers of the "Safety Last" class should be immediately eliminated.

II. Material and Equipment

Before work starts, the rigging and tackle, if it has been used before, should be thoroughly inspected and overhauled. All rigging should be frequently inspected. Such equipment, when subjected to heavy wear and tear, should be inspected daily. It is very poor economy to use worn-out equipment.

Chain slings are dangerous; wire rope slings are better than chain or fiber rope. If chain slings are used, they should be annealed at intervals, depending on the strains to which they are subjected. An endless cable makes the safest sling. Ends of ropes or cables used as slings should be spliced to form loops, and the loops lined with sheet metal thimbles to withstand wear. Protect slings when drawn over a short corner. When using multiple slings, adjust to carry equal stress. All slings should be securely lashed to prevent slipping on heavy lifts.

Whenever derricks, lashings, ropes, guys, ginpoles, and the like are used, they should be installed by riggers. All rigging, no matter how insignificant, should be done under the supervision of a rigger.

See Section XXXI.

Section XXII
ROPES

I. Uses

The wire rope commonly used on construction work is made of six strands of nineteen wires each, twisted around a hemp center. Three materials are generally

used in its manufacture—iron, crucible steel, and plow steel.

The last two, because of their combined strength and flexibility, are used principally for hoisting, transmission, and on excavating equipment. Frequently, rope removed from this service is again used for guying towers and derricks and as lashing and slings.

For hints on care and use of rope, see National Safety Council's pamphlet No. 26, "Manilla and Wire Rope."

II. Strength

Iron rope has about 40 per cent and crucible cast steel about 85 per cent of the strength of a plow steel rope of the same diameter. (See Section XXXI, Table XIII.)

Iron rope when bent with the hands has not the tendency to spring back that crucible or plow steel ropes have, and may be identified in this manner; but the difference in spring between the crucible and plow is hardly perceptible, and the test is not sufficiently reliable to determine the quality of the rope.

III. Factors in Wear

Three major factors govern the life of wire rope: external wear, internal wear, and kinking. A new rope presents only the surface of one or two wires of each strand to external wear. Friction against the sheaves, augmented by gritty substances contained in the dust and dirt, wear these outside wires and reduce their sectional area.

As the process continues, the next adjacent wires begin to wear, but rarely more than three wires of any strand present a wearing surface to the sheave before one wire breaks. This failure increases the load on the other wires, and with their decreased sectional area they fail rapidly.

To reduce external wear on rope, it is essential that the sheaves be properly aligned, and that the grooves

be kept in good condition. Sheaves with broken flanges or of improper size increase the wear on the cable and also the hazard of the line jumping the sheave

Running lines should be clear and well lubricated, and should not be allowed to wear against any abrasive surface. The choice of hard or soft sheaves depends upon existing conditions. In some instances it is more economical to replace the sheave than the line; in others the opposite is true.

A rope should be replaced, according to the Bureau of Mines, when the diameter of the outside wires has been worn to 65 per cent of their original diameter, or if 6 broken wires appear in one twist or lay of 6 x 19 rope. It is recommended that rope be discarded if 5 wires are broken with 10 per cent wear on outside wires; 4 wires are broken with 20 per cent wear on outside wires; and 3 wires are broken with 30 per cent wear on outside wires.

Internal wear is another factor affecting the life of wire rope. Being stranded, there is considerable internal motion in rope as it passes over sheaves. The outside wires are stretched more than the ones adjacent to the sheave. This unequal stretching causes internal motion which, unless the rope is thoroughly lubricated produces excessive wear.

Where the rope is subjected to reverse bends, this stretching shifts from one side of the rope to the other, increasing the internal motion and consequently the internal wear. The smaller the sheave, the greater the stretch in the outside wires. Wire rope manufacturers recommend sheaves of a diameter in feet equal to 4 times the rope diameter in inches for crucible steel or plow steel rope.

A third major factor is kinking. This is probably the most frequent cause of wire rope failure, and little warning is given of the weakened condition. Great care should be exercised in taking wire rope from the reel to avoid kinks. It is a good plan either to roll the reel

along the ground or mount it and run the rope off as needed.

New wire ropes frequently snarl when a clam shell turns over or a load slips. Such occurrences often produce kinks and sometimes snags. Snarled lines should be straightened very carefully and inspected for snags or kinks before re-use.

IV. Clamps

The easy adaptability of U-bolt clips for cable connections is responsible for their extensive use in preference to other types with greater efficiency, such as leaded sockets or wedge socket connections. Clip connections can develop efficiencies of better than 80 per cent, but connections of this strength are rarely found.

The U-bolts, when drawn too tight, crush the rope at the point of application, and kink the strands. If the U-bolts are placed on the free end of the line, the friction around the thimble reduces the load on the line at the clip, thus offsetting in a measure the decreased strength due to the crushing effect of the bolt. When applied in the opposite manner the full load is subjected to the weakened section directly under the bolt. Better connections are made by using more clips rather than fewer in such a manner that the rope is crushed.

The Eureka Metal Products Corporation of Buffalo, N. Y., manufacture a cable clamp having a forged steel "jaw" peened to the U-bolt in such a way that the cable is held between two "form-fitting" surfaces rather than between the bolt and one "form-fitting" surface as is the case with the ordinary clamp. This feature, it is claimed, eliminates the crushing action of the plain bolt on the cable. This clamp is sold under the trade name "Eureka."

Clip connections on new lines should be watched very carefully until the line takes its stretch. As the strands adjust themselves under load and compress the hemp center, the rope decreases in diameter, thus loosening

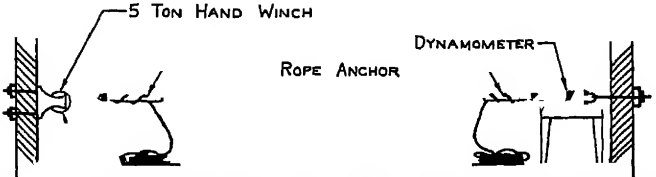


Fig 11—Rope Testing Set Up Safety Guard Screens at Both Ends Not Shown.

the clips. The wedge socket has advantages over other connections in efficiency, but is more expensive and does not have the adaptability of the clip.

V. Testing Non-Metallic Rope

Many serious defects in non-metallic rope cannot be detected by visual inspection, and, since economy requires repeated re-use, a practical means of testing is essential. The following procedure has been used successfully by one large company:

A hand winch and dynamometer are anchored some distance apart (Fig. 11). The ends of the rope to be tested are attached to the winch and the dynamometer, respectively, by a special rope anchor, and the desired load is applied. The load is predetermined, and depends on the size and condition of the rope under test.

The success of this method of testing lies in the design of the rope anchor (Fig. 12). These anchors are made of pipe varying in diameter with that of the rope to be tested. The rope is held by friction and snubbing, and is wound on the anchor to duplicate the stresses set up over sheaves. Table V shows the diameter of anchors for various sizes of rope.

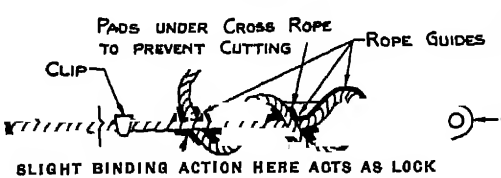


Fig. 12 — Details of Anchor Used for Testing Rope

TABLE V

Anchor Diameter for Different Sizes of Rope

Size of Rope In.	Diameter of Anchor In.
⅜ to ½	2¼
⅝ to ¾	3½
⅞ to 1	5½
1⅛ to 1⅜	8

VI. Block Efficiency

Tests were also conducted to determine the efficiency of steel and wooden block rigs with various numbers of sheaves. The sheave diameters were 1½ and 3 in. respectively. Dynamometers were used to measure the pull on the load and dead end of the tackle and on the fall line. Tables VI and VII give the results of these tests.

TABLE VI

Rope Testing Using Small Steel Blocks

No. of Sheaves	Pull on Fall Lines Lb	Dead-End Pull Lb	Load-End Pull Lb
1	500	900	400
2	500	1,250	750
3	500	1,600	1,100
4	500	1,800	1,300
5	500	1,950	1,450
6	500	2,000	1,500

TABLE VII

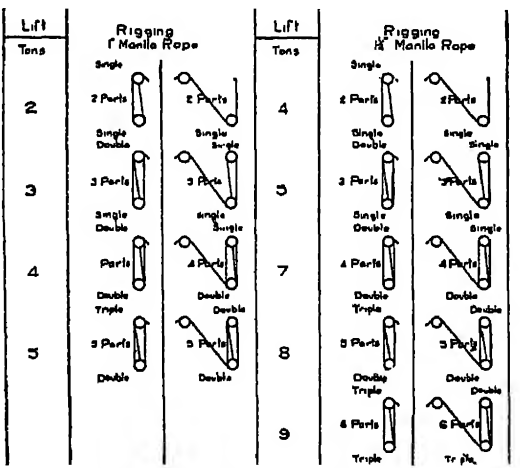
Rope Testing Using Large Wood Blocks

No. of Sheaves	Pull on Fall Lines Lb	Dead-End Pull Lb	Load-End Pull Lb
1	500	950	450
2	500	1,400	900
3	500	1,800	1,300
4	500	2,150	1,650
5	500	2,550	2,050
6	500	2,800	2,300

The efficiency of a block and tackle rig depends largely on the size and flexibility of the rope, and the diameter and number of sheaves.

Tables VIII to XI inclusive give the safe lifting capacity and fall line pulls on a few common systems of block and tackle.

Table VIII—Lifting Capacity of Tackle—Wooden Shell Blocks with Manila Rope.



12" blocks for 1" and 1¼" rope
Capacity of blocks with hook
Single—5 tons, Double—7 tons; Triple—8 tons.
Approximate pull on lead line
1" rope—1 ton; 1¼" rope—2 tons.
14" blocks for 1½" rope.
Capacity of blocks with hook·
Single—6 tons; Double—10 tons; Triple—12 tons
Capacity of blocks with shackle Quadruple—14 tons.
Approximate pull on lead line, 3 tons.
These values are only for tackle as shown. If lead line is snatched or passes over additional sheaves, capacity diminishes.

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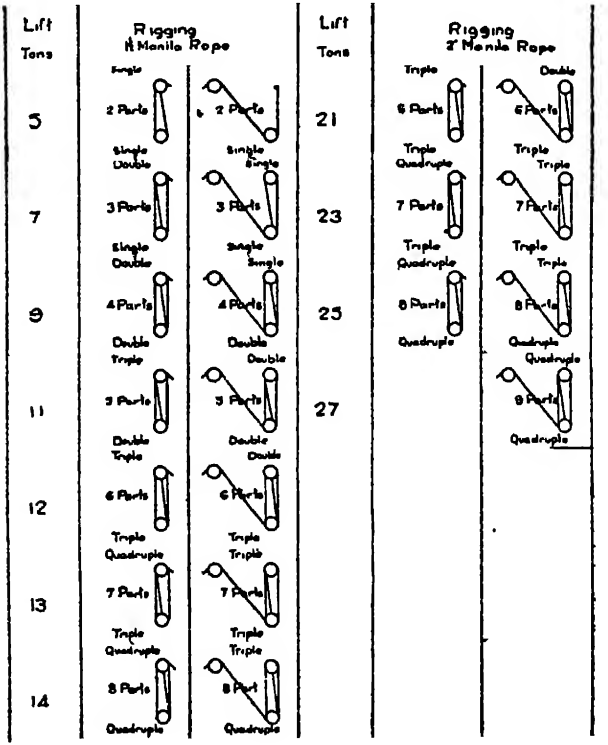
Table IX—Lifting Capacity of Tackle—Wooden Shell Blocks with Manila Rope



20" blocks for 2" rope.

Capacity of blocks with shackle:

Single—15 tons; Double—22 tons; Triple—30 tons; Quadruple—35 tons

Approximate pull on lead lines, 5 tons.

These values are only for tackle as shown. If lead line is snatched or passes over additional sheaves, capacity diminishes.

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Table X—Lifting Capacity of Tackle—Steel Shell Blocks with Wire Rope.

Lift	Lead Line Pull	Rigging 5/8" Wire Rope		Lead Line Pull	Rigging 3/4" Wire Rope	
Tons	Pounds	Double	Single	Pounds	Double	Single
10	5700	4 Parts, Double	4 Parts, Double	7400	3 Parts, Single	3 Parts, Single
20	8500	6 Parts, Triple	6 Parts, Triple	9800	5 Parts, Double	5 Parts, Double
30	10800	8 Parts, Quadruple	8 Parts, Quadruple	11700	7 Parts, Triple	7 Parts, Triple
40	10700	Six Sheave, 13 Parts, Six Sheave		13400		9 Parts, Quadruple
60				16800		Six Sheave, 13 Parts, Six Sheave

Table XI—Capacity of Tackle—Steel Shell Block with Wire Rope

Lift	Lead Line Pull	Rigging 7/8" Wire Rope	
Tons	Pounds	Double	Single
10	7500	3 Parts, Single	3 Parts, Single
20	11000	4 Parts, Double	4 Parts, Double
30	12800	6 Parts, Triple	6 Parts, Triple
40	15000	8 Parts, Quadruple	8 Parts, Quadruple
60	19000		5 Sheave, 11 Parts, 5 Sheave

Best crucible cast steel hoisting rope, 6 strands, 19 wires to a strand and hemp core.

These values are only for tackle as shown. If lead line is snatched or passes over additional sheaves, capacity diminishes.

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Section XXIII
CONCRETE AND MASONRY

I. Forms and Scaffolds

When old lumber is to used, it should be cleaned and all nails removed before being sent to the job. Since forms are but temporary structures, the tendency is to erect them with the least possible scaffolding. Scaffolds for form erection are as important as any others and should be as well erected.

Use mud sills under all shoring that rests on the ground, and see that shores are properly braced. When hoisting large sections, guide lines should be attached to keep them in control in case of sudden wind.

Before stripping a panel, place shores and ledges to support it. The removal of forms is in a class with wrecking, and is hazardous. "Slap-bang" removal is dangerous, is no faster, and is more destructive than orderly dismantling.

Protruding nails are the chief source of accidents on form work, sometimes resulting in serious infection and loss of members. Insist that workmen report all nail accidents, even the apparently trivial scratch.

II. Concreting

Hoppers should have a railed platform for men and protection below to catch the spill. With an elevating charging hopper, operator must see that men are out of danger before the hopper is lowered. Keep mixers clean and do not let waste material accumulate. Gates over openings should be controlled from above or from the side.

Build tripods strong and workmanlike. Guy spouting firmly, so that it cannot be blown by wind or fall. Always flush out spouting at the end of each run.

Runways should be solidly built with a smooth surface of ample width, and not inclined so steep that men will slip. Elevated runways should be railed.

See that buggy handles do not extend beyond the wheels on either side. Do not use wheelbarrows with split handles. Wheels must be strong, true running, and well secured to the frame. Never allow men to move a wheelbarrow with the handles in an upright position.

While concrete is being poured, have carpenters watch the falsework. Forms should not be removed prematurely. Be sure concrete is properly set—not frozen.

III. Brickwork

Brick basement walls should be strongly braced to stand any load which they may receive during construction. Do not backfill against green walls, nor allow loads to cause vibration, before proper setting of walls. High walls require good bracing against wind pressure during erection.

When working at stair wells, near edges of floors or other openings, bricklayers should not chip brick or drop pieces over the edge. Never put guys or other stays through brickwork until it has firmly set, and then only in places that will safely withstand the stress.

IV. Stone Masonry

Provide goggles for stone cutters. If other workmen or the public are exposed, screen in the cutting area. In handling stone, take care not to injure the scaffold or men. Stone should have proper holes to insure against slipping. See that the correct type and a sufficient number of anchors are used so that stone cannot loosen either during or after construction.

Section XXIV
STEEL ERECTION

I. Erecting

Steel erection is extremely hazardous, and there are few safeguards in some of the operations. Dependence must be placed largely on the caution, skill, and good judgment of the workmen themselves.

Riding the loads, hooks, cables, or slings of the hoists, and sliding down ropes, cables, or columns should be prohibited where possible. In severe storms and winds, and also when the steel is icy, work ought to be suspended.

Tools and material must not be left lying on beams. Before quitting time all loose objects must be secured against wind.

II. Hoisting

In hoisting loads of structural steel, a guide line should be attached and a man at the loading level guide the load. When raised, the load should be "boomed over," and the men at the erecting level should pull the load to its location, using the guide rope. This largely avoids the danger when men on beams have to move the loads into position by pushing or pulling.

III. Riveting

Platforms for forges should be at least 8 x 13 ft, be provided with railings and toe-boards, and located as near the riveting as practicable. These platforms are frequently moved, but should be solidly fixed at each location.

Never throw rivets across openings or toward the outside of a building. At outside walls throw the rivets parallel to the wall or, preferably, pass them by hand.

IV. Safe Clothing

Rubber soles and heels give surer footing than nailed leather shoes. Gloves are indispensable, but gauntlets, especially stiff ones, may catch on a projection, and their use should be discouraged. Workmen need to be careful at all times that their clothing does not catch, causing them to trip or fall. Loose, baggy clothing is dangerous.

Section XXV
SCAFFOLDS

I. Types

There are two main types of built-up scaffolds: the single pole type in which one end of the put log rests on the wall, and the independent pole scaffold. The latter type is much superior and should be used where practicable. Outrigger scaffolds for cornice and other light work are not favored if another type can be used.

II. Erection

See that the uprights rest on solid foundations and are fixed to prevent slipping. If uprights must be spliced, use cleats not less than 4 ft long and well nailed to opposite sides of uprights at the joints. Joints should be staggered. Cross-braces in one direction should be used between each pair of uprights. If window braces are used, see that the window frame is securely fastened in wall; but it is better to pass the brace through the window and secure it at the floor.

Lay platform planks lightly together, fastened so that they cannot tip under weight, and overlapping at least 12 in. at each end. Erect guard rails and toe-boards along the outer edge of scaffolds. Above the fifth floor heavy wire netting or boards should fill in the space between the toe-board and the rail.

When work is going on above men working on scaffolds, overhead protection should be provided in a roof of light lumber, heavy canvas, or heavy wire screen. Safe access should be provided by stairs or a permanent ladder. Fasten the upper end of ladders so they cannot tip or slip.

III. Care

Never allow any part of the scaffold to be removed until the use of the whole structure is completed. Protect the scaffold from trucks and equipment striking or dumping material against it. Do not let hoisted loads swing against or catch on scaffold.

IV. Use

Do not use scaffolding built by others until after careful inspection. Do not overload scaffolds. In winter remove snow and ice before starting work, as these make a needless load on the structure. Sprinkle the platform with salt to prevent slipping in cold or wet weather. Men should not work on scaffolds in storms or high winds. Nothing should be dropped onto or thrown from a scaffold, and men should not jump or wrestle on them. Work underneath and around the base of scaffolds should

Fig. 18—A Safe Swinging Scaffold.

be as infrequent as possible when men are on the upper levels.

V. Pipe Scaffolds

Pipe scaffolds should be of common pipe, and free from scale. Couplings should not be used. There should be a hanger for pipe beams every 8 ft. See that the supporting ropes cannot slip off the ends of the pipe. Bolts through pipes, near the end, are desirable.

Recent developments in patented pipe locked scaffolds are a marked step forward in lessening fire hazards on construction work, since they provide an all steel scaffold support. They also afford rigidity as well as pleasing appearance.

VI. Swinging Scaffolds

Hooks, anchors, and outriggers for swinging scaffolds should be well secured. Timber needle beams must be strong enough for the load. Shackles or beam clamps holding the cable need to be well fastened to the outriggers. A stop should be placed at the outer end of the outrigger. Swinging scaffolds should be lowered to ground or lashed to the building when the men leave

VII. Temporary Scaffolds

Light, temporary scaffolds built up to make repairs should not be made in a makeshift manner. Many accidents occur on temporary scaffolds, and they should be strongly built of good material.

See Section II.

Section XXVI
TEMPORARY FLOORS

I. Use

If the permanent floors are not following to within three stories of the steel erection of a building, a temporary protective floor should be laid not more than three stories, or 30 ft, below the highest level on which the steel erectors are working. In the case of bridges, docks, coal handling equipment, or similar structures spanning open spaces more than 30 ft above the ground, a sub-

stantial platform should be constructed on or suspended from the structure, not more than 6 ft below the bottom chords.

In all except steel buildings, the permanent floor should be completed to within two stories of the highest scaffold.

II. Construction

Temporary protective floors should be constructed of not less than 2-in. lumber, with maximum spans of 8 ft. Temporary intermediate joists are needed if the permanent beams are more than 8 ft apart. Extend planks at least 1 ft beyond their supports, or nail them to prevent slipping. No openings should be permitted in these floors except those necessary for handling of materials, stairways, and ladders.

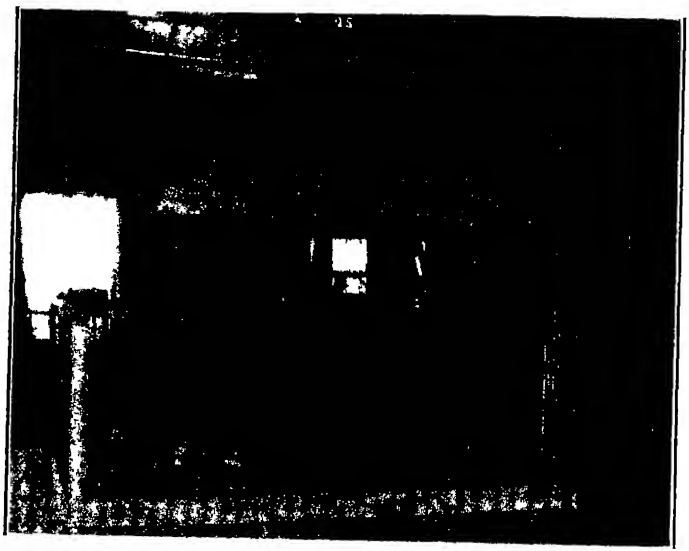

Fig. 14—Stairway Openings Correctly Protected with Railings and Toe-Boards.

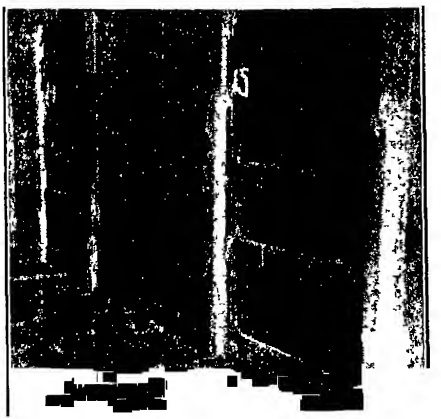

Fig. 15—Strong, Safe Barriers Protecting Door Openings

All outside edges and floor openings should have toeboards. Hoistways and other openings need guard railings, substantially braced. If it becomes necessary to remove any of the floor temporarily, it should be immediately replaced.

Section XXVII

SUB-CONTRACTS

It is not sufficient that the construction company limit its safety supervision to its own work. Where construction work is done by outside contractors, safety supervision should still be maintained. One large company includes in every contract for construction by other firms the following provisions:

In the performance of this work the contractor further agrees:

(a) Precautions—To take, use, provide and make all proper, necessary and sufficient precautions, safeguards and protections against the occurrence or happening of any accidents, injuries or damages to any persons or properties during the progress of the work covered by this agreement;

(b) Indemnification—To be responsible for and to protect, indemnify and save the company harmless from and against the payment of any and all sums of money by reason of any accidents, injuries or damages to persons or property which may happen or occur upon or about said work, or arise by reason thereof from a cause not attributed to negligence on the part of the company;

(c) Insurance—To be bound by the State Workmen's Compensation Act as to the contractor's own employes and those of any other person to whom a portion of this work may be sub-let while any of such employes are engaged upon this work, and to carry adequate Workmen's Compensation Insurance as well as Public Liability Insurance, the latter to be for not less than $..... for any one person, and $..... for any one accident. These policies shall be in the usual form and shall conform to the laws of the State. The contractor shall furnish the company with an insurance company's certificate to the effect that such coverage has been provided, the certificate to contain the date when the coverage expires. Said certificates shall be furnished to the authorized representative of the company before any of the employes of the contractor shall do any work upon the premises;

(d) Releases—In the settlement by the contractor of any claims growing out of accidents, injuries or damages in connection with this work to the contractor's employes, or to any other persons or property, to have the company likewise released from any liability therefor, and to furnish the authorized representative of the company with a duplicate of the release properly executed;

(e) Sub-letting—That no portion of this work involving the furnishing of labor for construction or erection shall be sub-let to any other contractor without the approval in writing of the authorized representative of the company;

(f) No liens to be filed—That no lien of any kind whatever shall be filed by the contractor, or any sub-contractor under the contractor, or by any other person, firm or corporation against the said property for any work performed, or for any material furnished, for the construction of the work herein contracted for, or any work incidental thereto; * * *

PART C—INSTALLATION OF MACHINERY AND EQUIPMENT

Section XXVIII
HYDRO-ELECTRIC

I. General

The interest and insurance charges during construction are high, and it is often economy to work with all possible speed. Usually the terrain at the power house is rough and rugged, and transportation facilities are limited. Heavy machinery and equipment are often skidded or hoisted to the site. Eating, sleeping, and sanitary facilities are temporary, and the work is generally more hazardous than ordinary construction projects.

II. Location

1. *Walkway, Stairs, and Ladders.* Hydro-electric projects are usually located on streams between bluffs of steep hills. Safe walkways for workmen should be provided, especially between the camp and site. Stairs and ladders are frequently necessary, and should be safely constructed. (See Section II.)

2. *Natural Location Hazards.* Bluffs or hills should be cleared of loose stones, logs, and the like, that might later fall or roll onto the site. Forest fires should be guarded against. Formations of ice and snow should be watched, as they may develop into snowslides.

III. Construction Camp

1. *Location.* The first consideration in locating a camp is safety from floods. It should be convenient to work, protected against forest fires, on solid ground and well drained.

2. *Building the Camp.* The plot should be laid out for convenience, and recreation provided. Streets should be surfaced or otherwise protected against the formation of mudholes. The buildings should be well constructed and designed to meet expected weather and climatic conditions. Sleeping and eating quarters should be screened.

The mess hall must be well ventilated and easily cleaned Fire extinguishers should be conveniently located.

3. *Sanitary Provisions.* A source of healthy drinking water must be provided and tested at regular intervals Ample bathing facilities are necessary. Sewage and rubbish must be disposed of in a sanitary manner.

4. *Medical and First Aid.* Medical attention will be constantly needed. A doctor or trained nurse should be available. Drowning is always a hazard to this work. A first aid team should be organized as work starts.

IV. Clearing Site

Clearing, blasting, and excavating in the early stages of development are very hazardous. Felling trees, moving logs and boulders should be carefully supervised.

Blasting should be done after working hours, between shifts, or after all workmen have been notified. Where a large amount of blasting is necessary, a warning signal should be devised. (See Section X.)

Frequently, on isolated projects, large amounts of excavating are done by hand. Cave-ins are particularly hazardous. No work, especially trucking, should proceed near the edge of excavations in which men are working. (See Section XVII.)

V. Transportation

1. *Temporary Roads.* Roads on most hydro-electric projects are temporarily constructed and poorly ballasted and surfaced. They frequently follow hazardous courses along the side of the hills and near bluffs. For these reasons all trucking should be done by expert drivers. Damage to roads, particularly landslides, should be reported at once. (See Section XIV.)

2. *Temporary Railroads.* When the project warrants a railroad, it should be completely organized. The equipment should be handled by experienced operators. Only brakemen should ride on loaded cars. They should never ride on dump cars. Passengers should never be hauled in dump cars, loaded or empty.

Unless specially designed, dump cars should always be

latched when in motion. Care must be used in loading cars, especially when they are to be hauled on trestles over workmen. Trains should be operated at safe speeds, due consideration being given to condition of track.

The dump or grade should be in charge of a reliable man. Active dumps or grades should be properly guarded and marked with signs. (See Section XV.)

VI. Forms

Concrete forms on hydro-electric projects are usually extensive and intricate, and are in constant hazard to floods. They should be provided with well-guarded scaffolds and walkways. Ladders should be carefully constructed and anchored, and stairs used where possible. (See Section XXIII and Sections XXXV and XXXVI.)

VII. Concreting

Large volumes of concrete necessitate the use of heavy mixing machinery and intricate systems of spouting. Safe structures must be provided for all machinery. Conveyors should be protected with guards. Workmen should be forbidden to ride on material conveyors. (See Section XXIII.)

VIII. Equipment

In addition to turbines, generators, and the like (see Section XXIX), there is considerable equipment peculiar to hydro-electric installations alone to be installed and adjusted. The installation of penstocks, surge tanks, and similar equipment is extremely hazardous because of their awkward locations. Complicated hoisting is frequently necessary. Work is done on steep slopes with little or no scaffolding.

The installation and adjustment of flashboards is hazardous and requires careful supervision. Final adjustments around and near penstock intakes should proceed with caution. Swimming near the mouth of intakes must be prohibited. Chains are frequently placed near the intakes to afford a means of escape in case a man loses his balance.

Section XXIX
TURBINE ERECTION

I. Organizing a Crew

1. *Personnel.* Turbine erection is usually done under the supervision of an experienced erector provided by the manufacturer, who may have a few expert mechanics with whom he is well acquainted; but a large proportion of the work is actually done by mechanics and laborers picked up at the power house site, who have not been schooled in any kind of safety work. Under these conditions such a crew requires careful instruction before work starts.

2. *Safety Instructions.* The turbine erector should give detailed instructions to each member of the crew as to how he wants work done on this particular job. Even on small crews it is well worth while to appoint some member as a safety inspector to check up on the various safety details which must be watched throughout the program of erection.

II. Unloading Equipment

1. *Facilities.* As a general rule the first work of the turbine erection crew is to get the equipment off the cars. In most large plants a traveling crane is available to lift parts directly from the cars. However, there are many plants where it is impossible to run the cars in under the turbine room crane, and a great deal of safety precaution is necessary.

2. *Safety Precautions.* Whether the unloading is done by crane or by skidding, a high quality of gang discipline is necessary. Crane operators should take signals from one man only when moving any particular load. When skidding, care must be taken that solid timbers are selected, and cribbing built in accordance with the load to be carried. Every move must be made after direct orders from the foreman in charge. (See Section XIV.)

III. Lifting Rigging

Flexible steel slings of the best quality should be used. Sharp corners should be avoided when rigging for a heavy lift. Chains should never be used in turbine erection work. Material or equipment should not be lifted or moved over workmen. (See Section XXXI.)

IV. Storing Parts

Due to the great weight of some turbine parts, care must be exercised to avoid overloading any of the turbine floors. The parts should be spaced properly for cleaning and inspection before assembling. Clear walkways should be left.

V. Uncrating Parts

Great care should be taken in uncrating parts. Used crating should be disposed of immediately after uncrating is finished. All parts and material should be placed in a stable position before uncrating is started.

VI. Floor Openings

During turbine erection there are generally a number of large openings in the turbine room floor, such as the one where the unit will be erected. These should all be protected by railings. Care must be taken to protect the men working below. The opening over the condenser before the exhaust cap is erected is very dangerous and should be planked as soon as possible. (See Section XXVI.)

VII. Assembling of Turbine

1. *Lifting and Hoisting.* When lifting and carrying parts with traveling crane, workmen must not ride loads. They should never stand under lifted loads. When swinging the parts into place, workmen should not stand in the path. The failure of the crane controls might cause a very serious accident. (See Section XXXI.)

2. *Preliminary Assembly.* The sledge-hammer is the tool most frequently used in turbine assembling. It must be used in positions where it is very difficult to get the

proper foothold, and in these cases scaffolds should be built, particularly for setting up the heavy bolts in the joints of the turbine casing. Sledge-hammer strikers should be carefully schooled in their work. A striker should never strike toward the man holding the wrench.

3. *Final Assembly.* In tightening up bolts in the high pressure part of the turbine, it is customary to heat the bolts while drawing them up with wrenches. Such bolts should always be marked to indicate that they are hot, and prevent other workmen being burned.

Section XXX
BOILER ERECTION

I. General

Boiler erection is more hazardous than the erection of ordinary machinery because work is carried on simultaneously at a number of different levels, and by representatives of many different firms. A boiler is composed of heavy parts, and usually there is no provision for handling heavy loads. Moreover, boilers are generally assembled with the building steel work and the ordinary hazards are supplemented by those of the building trades.

The erectors for all firms involved in a boiler installation should carefully instruct their crews in the rules of safety. They should be furnished the weights of all heavy units, and tables of safe loads on various kinds of rope, chains, and timbers commonly used for heavy lifts.

II. Unloading Material and Equipment

When a crane is not available for handling the boiler drum, it should be shipped on a flat car to facilitate unloading at the job. All lashing, bracing and the like should be removed cautiously. The load may have shifted and placed members under tension, causing them to rebound when removed.

Cribbing or sills used in rolling or skidding the boiler

drum should be carefully checked for strength. Temporary or new floors should be inspected before moving the boiler drum or other heavy equipment over them.

Tube sections of cross drum type boilers are usually shipped in a vertical position, and are hazardous to unload. All sections should be lashed together; each section being released as it is removed. When lifting these sections, the slings should be attached to a number of tubes to equalize the strain.

Hairpin type superheaters are often shipped assembled and are awkward to handle. The same safety precautions should be applied to these as to boiler tube sections. It is safer to ship dismantled and assemble the superheater units on the job.

Stay-bolts, castings and the like should be stored in an orderly manner and in a stable position. Grate bars and similar material should be securely braced when stacked or piled.

All material should be stored with consideration to the order in which it will be used. Aisles should be provided through the material space to give access to all points on the floor. (See Section VIII.)

III. Scaffolds and Walkways

Care must be exercised in building ladders, walkways and hand railings that they are safely and strongly constructed. Every scaffold should have toe-boards. All hanging scaffolds should be erected by riggers, and post and ledger scaffolds erected by carpenters employed by the general contractor. In this way, unsafe scaffolds, which might be erected by the sub-contractor, may be avoided. It also places responsibility in case of a collapse.

Men working in one location, such as bricklayers, should be protected from danger of falling objects by a temporary covering. Hand tools and materials should not be laid carelessly on a scaffold or places where they

might be pushed off. Workmen on so many levels make falling objects a particular hazard to boiler erection. (See Section XXV.)

IV. Hoisting

Care is necessary that hoisting tackle is not attached to loose or temporary structures. It must be of sufficient strength to withstand the shock of catching or irregular lifts. The fall line of hoisting tackle should pull clear of obstructions and to a point where workmen can get a good footing.

When a hoisting engine is used, it should be the correct size, and securely anchored. Care must be exercised that hoisting ropes or cables are not overstressed on a power winch. Do not "dog" the load on the engine. The load should always be stopped by the engine brake.

Raise loads slowly and steadily. They should pass clear of all obstructions, or be guided by a line. Time the hoist so that load can be landed promptly as soon as it reaches the proper height. (See Section XIX.)

V. Handling Tools and Material

Hammers, wrenches and other hand tools should be held firmly, as one dropped may cause a serious accident. A hammer or similar tool that is loose on the handle should never be used.

Small pieces like nuts, bolts and small castings should be handled carefully at all times. Small objects, especially, should not be laid in a walkway. They form dangerous tripping hazards. Tripping or stumbling on an elevated walkway very frequently results seriously. (See Section XIII.)

PART D—POWER STATIONS

Section XXXI

RIGGING AND HANDLING

Analysis of accident reports proves the rigging of apparatus to be a source of frequent and serious accidents.

I. Rigging Gangs

Rigging should not be undertaken except under supervision of an experienced and skilled rigging foreman, and with a large proportion of experienced men in the gang.

II. Premises

Premises should be examined carefully regarding the points of support, and route which load must traverse. Examine nature of earth fill, timber, steel or reinforced concrete structures, floors, roof trusses, scaffolding, bridges and street surfaces, which must sustain heavy loads. Power house floors are often so designed that additional cribbing is necessary to distribute loads to main bearing columns. Frequently street surface will not sustain heavy transformers over sewers, larger manholes, subways, etc.

III. Rollers

Roller must be placed so as to avoid crushing fingers and toes. Always work from side, never in front of roller. When not in use, rollers should be placed where no one will trip or lose footing on them. Rollers should be placed so as to divide load evenly without causing undue strains on apparatus parts. Skids may be necessary. Not all bases are self-supporting. Wooden rollers may not be usable if the supported parts have sharp edges. In that case use steel rollers.

IV. Removing Packing

Always remove or drive in nail points. Loose timber

should be stacked out of the way in a manner not liable to cause falls or shifting of pile. Preferably unbox in locations other than in congested or operating stations. Remove excelsior at once.

V. Rigging Timber

Pile so as to prevent falling or causing tripping or congestion. Use two man carry for six foot or longer pieces of board in operating stations. Do not carry timber on shoulders. Street obstructions must be lighted by night.

VI. Hydraulic and Screw Jacks

Hydraulic and screw jacks must be examined before use. Set carefully to avoid tipping or slipping out from under load. Use jacks with remote control dogs.

VII. Cribbing

Cribbing must be piled evenly and stayed to prevent swaying. Only wide pieces should be used in order to obtain greater stability, especially during the raising of load.

VIII. Wedges

Wedges used for leveling should be protected so as not to cause tripping, or bruising of insteps and ankles.

IX. Clamps and Hooks

Clamps and hooks must be tested for soundness before using, and should have load capacity plainly indicated.

X. Hoisting

Use danger signs to warn pedestrians of danger overhead. Danger zones should be barricaded or roped off.

XI. Hitches

Hitches for hauling should be made well below center of gravity and as near floor as possible. Hitches for hoist should, of course, be well above center of gravity, and for draft (on skids or rollers) well below the center of gravity. (See cautions regarding use of eyebolts in

General Electric Company "Cautions" reprinted below.)

XII. Prys

Only solid bars should be used, never pipes, and seldom timbers. Care should be taken in close quarters to avoid pinching hands on adjacent parts.

XIII. Backstays

When there is the least danger of load "getting away" or out of control, effective backstays should be used.

XIV. Stability

Some pieces of electrical apparatus, such as regulators, are liable to tip. Long skids are desirable. Care should be exercised to keep them on "even keel" while moving, and apparatus should be bolted to skids when possible.

XV. Safe Load Limits

All hoisting and strained parts should have safe load limits conspicuously marked and checked before use with load to be sustained.

XVI. General Electric Co. "Instruction to Crane Followers"

The following matter is quoted, with slight changes and additions from "Instructions to Crane Followers and Others in Use of Slings and Making Hitches," an instruction book of the General Electric Company.

CAUTIONS

I. General

Take no chances in estimating the weight of the material to be lifted. Weights can readily be calculated. (See Fig. 16, 17, 18 and explanatory text.)

DO NOT walk nor stand under a suspended load. Allow no one else to do so.

DO NOT ride on a load.

DO NOT carry a load over human beings. If it is necessary to carry the load in their direction, warn them.

Be careful when handling small pieces. More accidents occur due to carelessness when handling small pieces than when handling larger parts.

When in doubt ask your foreman for advice.

Remove all loose pieces that may be lying on work to be lifted. For instance, in hollow castings look inside for loose pieces, such as bolts, straps, blocking, etc.

Mark all parts of hoisting equipment with safe load limits.

DO NOT lift a piece of assembled apparatus without first making sure that the assembled parts are securely bolted. If in doubt, consult the foreman or his assistant.

DO NOT ask for information from anyone except your foreman or his assistant.

DO NOT use eyebolts on angular lifts unless absolutely necessary. If, however, it is found necessary to lift at an angle, consult Table XII carefully, as the capacity of the eyebolt drops rapidly as the angle of pull increases. For instance, it will be noted that a ½-in. eyebolt will carry with safety 1100 lb straight lift, but if the lift is at an angle of 90 deg or sideways on the bolt, it will, with the same degree of safety, carry only 37 or 38 lb, or only about one-thirtieth of what it would carry at a straight lift.

DO NOT neglect to place pads on all sharp corners with which ropes, slings and chains might otherwise come in contact, especially in cases where the slings might slide during the lifting operation.

Inspect the chains, hooks, shackles, bolts, etc., to see if repairs or replacements are needed. Never use apparatus having defects, such as flaws, cold shuts, or cracks of any kind in lifting. Never use a chain if the links do not work freely within one another, since such chain has been overloaded or misused. If the parts show long wear, anneal them. When badly worn or bent, scrap them.

Use neither wire rope nor Manila rope that has become badly frayed or worn in spots. Never use a wire rope having a sharp fixed kink.

NEVER load a chain hoist beyond its rated capacity, for that will cause the links in the chain to kink and bind.

NEVER make a hitch with the load chain and hook, for that causes kinks in the chain and weakens the hook.

Slings should be so placed that load is carried at back of hook.

II. Difference between Chains and Ropes

(See National Safety Council Safe Practices Pamphlet 6 and U. S. Government Std. Spec. No. 61 (Manila Rope).

There is a great difference between ropes and slings used

Table XII—Safe Load on Eyebolts When Loaded in Direction of Arrow.

Size of Eyebolt in Inches A Thread U S Standard		Dimensions B	C	L	Load in Direction of Arrow, Lb	Load in Direction of Arrow, Lb.	Load in Direction of Arrow, Lb
Drop forge steel 9000 combined stress in lb per sq in	½	1½	7/16	1½	1100	51 5	37 6
	9/16	1 9/16	17/32	1 5/8	1500	69 8	51 0
	5/8	1 11/16	5/8	1¾	1800	89 5	65 6
	¾	1 13/16	¾	2 1/8	2800	136 0	100 0
	7/8	1 15/16	13/16	2¼	3900	208 0	153 0
See Note	1	2 1/16	15/16	2½	5100	280 0	207 0
	1¼	2 5/16	1 3/16	2 7/8	8400	503 0	372 0
	1½	2 9/16	1 3/8	3¼	12200	770 0	576 0
	1¾	3 1/16	1½	3 5/8	16500	1080 0	805 0
	2	3 1/16	1 5/8	3 7/8	21800	1440 0	1140 0
Welded D B G. Iron E L. 2800 lb. per sq in 6000 combined stress in lb per sq. in	1¾	3	1¼	3¼	10000	800 0	600 0
	1¾	4	1½	4	11000	660 0	486 0
	2	5	1¾	4½	14000	884 0	655 0
	2¼	6	2	5¾	16000	1050 0	770 0

NOTE: Correction to Eyebolts The figure 9000 lb per sq in. refers only to the stresses in the shank. At pulls parallel to the shank the maximum stress at the inside of the sides of the ring and at the outside of the top, assuming a bar-in-eye lift, would be over 13,000 lb per sq in. This would still give a factor of safety of six

for hoisting. In ropes the wear can always be seen by the strands becoming frayed, loose or cut. A chain, except for a few bruises, will not show any signs of weakness, although it may be full of small cracks which cannot be seen by the naked eye, or it may be much crystallized by long use. Under these conditions a chain is rapidly becoming weaker with each lift, until it finally gives way, letting something fall on the man who used it, or, as is more frequently the case, on some innocent shopmate. (See Fig. 19 to 29 incl., Knots and Hitches. See U. S. Bur. Stds. Circular No. 208, Wire Rope.)

III. Wire Cable Slings

Wire cable slings occupy a very important place in hoisting, and have been found very satisfactory when carefully used. (See Fig. 30 to 35, inclusive, Wire Cable Slings.)

Never use a wire cable sling singly when hooked by a spliced eye. When the weight is sufficient the cable is liable to untwist, thus allowing the splices to open and slip. Always use such slings double, and where sharp corners or rough castings exist, protect the cable by pads. (See safe load limit under VI, below.)

Another method of protecting the cable is by two loose metal blocks. These should be free to adjust themselves.

In using slings of any kind, see that they are properly laid, that is, see that one rope does not lie on top of the other, as this will prevent proper equalization, putting an undue strain on the outer rope.

It very often happens when a rope sling is used double that the ends of the rope are passed through the doubled part, as when placed around a casting, and unless this is done carefully, instead of having the strength of two parts of a rope, as supposed, it can be so slipped around the casting, or other piece being lifted, as to have actually only the strength of one part.

IV. Lifting Motor-Generator Sets

Use great care in lifting apparatus of this kind. Use padding on all sharp corners. Adjust the slings so that each set will take its share of the load. Never loop Manila rope slings and wire cables through each other. The cable, being much thinner, will cut the rope, causing serious accidents and delays.

V. Sudden Stoppages of Load

'e lifting heavy loads by means of a crane always
: crane brakes to see that they are in a good con-
ınd will hold. When lowering loads limit the speed,
hould not exceed the hoisting speed of the crane for
ıe load. Take particular care to apply the brakes
ly when bringing the load to rest. The ordinary
· speed for a 30-ton motor operated crane is about
er min, and for a 50-ton crane about 12 ft per min
ɜ rated load.

·ing the load at such speeds within a short distance
ıble the stress on the slings and crane.

point cannot be emphasized too strongly, as in more
e ınstance serious accidents have resulted from the
stoppage of cranes while the load was being lowered.

'I. Increased Stresses Due to Angle of Slings

a weight is lifted by one or more slings connected
:rane hook and making an angle with the direction
he increase in the stress of each sling must be con-

On account of this angle between the line of lift
sling, the stress on each sling is greater than half
l load, and increases very rapidly as the angle be-
he sling and the line of lift is increased. An angle
eg makes the stress in each sling three-fourths of
l weight, and the collapsing forces between the two
ɔf attachment to the work are each one-half the

These collapsing forces act in a direct line between
ıts of attachment. If the work is ring shaped it
end to deform the ring. A spreader of sufficient
should be used between these points to resist this
ıg force. It will be seen that eyebolts are not suit-
attaching the slings to the work unless a spreader
to relieve them of this side pull, which would put
bending moment on the shank of the bolt.

ısing the angle to 60 deg from vertical makes the
ı each sling equal to the total weight, and the col-
forces almost equal the total weight. Such a small
ıould never be used if avoidable.

XIII gives the capacity of straight lifts and shows
safe load becomes very much smaller when the slings
l at an angle instead of a straight pull.

Table XIII—[illegible] Standard Table of Safe Loads for [illegible]

NOTE.—The safe loads in table are for each SINGLE rope or chain. When used double or in other multiples the loads may be increased proportionately.

Plow Steel Wire Rope	Diam. in In.	When Used Straight		When Used at 60° Angle		When Used at 45° Angle		When Used at 30° Angle	
		For General Use	For Molten Metal	For General Use	For Molten Metal	For General Use	For Molten Metal	For General Use	For Molten Metal
(6 strands of 19 or 37 wires)	3/8	1,500	1,200	1,275	1,000	1,050	800	750	600
If crucible steel rope is used, reduce loads one-fifth.	1/2	2,400	1,900	2,050	1,600	1,700	1,350	1,200	950
	5/8	4,000	3,200	3,400	2,700	2,800	2,200	2,000	1,600
	3/4	6,000	4,800	5,100	4,000	4,200	3,300	3,000	2,400
	7/8	8,000	6,400	6,800	5,400	5,600	4,400	4,000	3,200
	1	10,000	8,000	8,500	6,800	7,000	5,600	5,000	4,000
	1 1/8	13,000	10,400	11,000	8,800	9,000	7,200	6,500	5,200
	1 1/4	16,000	12,800	13,500	10,800	11,000	8,800	8,000	6,400
	1 3/8	19,000	15,200	16,000	12,800	13,000	10,400	9,500	7,600
	1 1/2	22,000	17,600	19,000	15,200	16,000	12,800	11,000	8,800

Crane Chain	Diam of Iron									

Crane Chain	Diam of Iron in In.							
(Best grade of wrought iron, hand-made, tested short link chain.)	¼	600	475	500	400	425	325	300	225
	⅜	1,200	950	1,025	800	850	650	600	475
	½	2,400	1,900	2,050	1,600	1,700	1,350	1,200	950
	⅝	4,000	3,200	3,400	2,700	2,800	2,200	2,000	1,600
	¾	5,500	4,400	4,700	3,700	3,900	3,100	2,750	2,200
	⅞	7,500	6,000	6,400	5,100	5,200	4,100	3,700	2,950
	1	9,500	7,600	8,000	6,400	6,600	5,200	4,700	3,700
	1⅛	12,000	9,600	10,200	8,100	8,400	6,700	6,000	4,800
	1¼	15,000	12,000	12,750	10,200	10,500	8,400	7,500	6,000
	1⅜	18,000	14,500	15,500	12,000	12,500	10,000	9,000	7,000

Manila Rope	Cir in In.	Diam. in In.							
(Best long fiber grade.)	1	⅜	120		100		85		60	
	1½	½	250		210		175		125	
	2	⅝	360		300		250		180	
	2¼	¾	520	DO NOT USE	440	DO NOT USE	360	DO NOT USE	260	DO NOT USE
	2¾	⅞	620		520		420		300	
	3	1	750		625		525		375	
	3¼	1⅛	1,000		850		700		500	
	3¾	1¼	1,200		1,025		850		600	
	4½	1½	1,600		1,350		1,100		800	
	5½	1¾	2,100		1,800		1,500		1,050	
	6	2	2,800		2,400		2,000		1,400	
	7½	2½	4,000		3,400		2,800		2,000	
	9	3	6,000		5,100		4,200		3,000	

[NOTE—Manila or wire rope slings with eyes have a safe load limit of one-half the safe load limit of the rope of same size given in tables.—Accident Prevention Committee.]

VII. Safe Loads for Eyebolts

When it is necessary to use eyebolts for lifting loads no greater strain should be allowed than given in the table, which gives the safe load in pounds up to and including bolts 2¼ in. in diameter. (See Table XII.)

It should be understood that to obtain the greatest strength from an eyebolt, it must fit reasonably tight in the hole into which it is screwed, and the pull applied in a line with the axis of the screw.

Eyebolts should never be used if considered the least faulty. They should never be painted when used for miscellaneous lifting, as paint is very apt to cover up flaws. They should be tested occasionally by tapping gently with a hammer while held in the hand. If it does not impart a good ring the bolt should not be used.

Where a bolt is to be used for anything like its maximum load, it should be screwed in tight with a bar and given a gentle tap with a bar or hammer to see if it imparts a solid feeling. If not, it should not be used.

The strains set up in an eyebolt when used at an angle are very severe, due to the bending action of the bolt, and it is very liable to break where it is screwed into the work. This is shown very clearly by Table XII, which gives the safe load when used for a direct pull, and also shows how the strength of the bolt rapidly decreases according to the angle that may be used.

The figures given in Table XIII are for cases where slings are in constant use and subjected to ordinary shop practice.

The loads for manila rope should be used only when the rope is in good condition. When badly chafed or worn, the load should be reduced in proportion, or the rope scrapped if there is the least doubt of its strength and condition.

As there are a great many different kinds of material to handle, and in order to familiarize those engaged in the actual handling of these materials, Table XIV of the weights of the various materials is given.

The weights of cast iron, steel, copper, lead, concrete, stone, earth, brick, mortar and marble are given in pounds per cubic foot.

Table XIV—Weights of Various Materials.

Material	Weight per Cu. Ft in Lb	Weight per Cu In. in Lb
Cast iron	450	0.26
Steel	490	0.28
Copper	552	0.32
Lead	709	0.41
Ash	45	....
Pine	38	....
Concrete	155	....
Stone	180	....
Earth	72 to 110	....
Brick	100 to 150	....
Mortar	100	....
Marble	180	....

Diameter in Inches	Weight of Shafting in Lb. per Lineal Ft.
6	95
8	169
10	264
12	380
14	517
16	676
18	855

The weight of shafts is given per lineal foot, or so many pounds for each foot in length. All that is necessary to find the weight of any piece of shafting, knowing the weight per foot, is to multiply the weight by the number of feet in length, which will give the net result in pounds to be lifted. For instance, a piece of shafting 16 in. in diameter, 1 ft long, weighs 676 lb. A piece of shafting of this same diameter and 16 ft long would weigh 10,816 lb. Provision in this case should be made for lifting at least six tons.

A wood or lag screw, when made in the form of an eyebolt, should never be used to hang any hoisting tackle on. Wherever it is possible, the safest way to hang such tackle is by passing the shank of an eyebolt through the floor or beam, properly protecting the wood by a large plate washer and nut. It frequently happens that a chain or rope sling can be used by passing it over a properly secured timber.

It is advised and urged in every case where a person is

in doubt as to the weights to be lifted, or methods employed, to seek advice from his foreman. It is also suggested and urged that all irregular shaped castings, and, in fact, all castings weighing over a ton, should have the gross weight marked in plain figures for the guidance of those engaged in handling or lifting pieces. It is always safer to overestimate a weight than to under-estimate it, and it is always safer to use slings of ample lifting capacity than those about which one is in doubt.

Do not use any material which you know or think is defective. When any defective material is discovered, call your foreman's attention to it immediately.

Other defects besides those in lifting apparatus will occasionally be discovered, such as a cracked arm of a flywheel or other similar piece. The worker should call his superior's attention to it immediately upon making such discovery.

Those engaged in this important class of work should always have some idea of the strength of materials. They should know how the strains will be set up in such materials, and also know how to apply slings for lifting. They should know that using wrong angle on the slings, as in the case of field ring, would tend to pull the sides together, and in the case of a revolving field the sling is applied around adjacent arms, and not between the arms.

These things are all matters of judgment, and the importance of appointing proper persons to have charge of this work cannot be urged too strongly.

(See Fig 30 to 51, inclusive, for methods of attaching slings and auxiliary hoist equipment.)

To calculate weights of variously shaped pieces, the following methods may be used:

Example

To find the weight of a shaft of sizes shown (see Fig. 16):

Wt 18 in. shaft 1 ft long = 855 lb × 7⅛ ft = 6,092 lb
Wt 16 in. shaft 1 ft long = 676 lb × 2½ ft = 1,690 lb
Wt 12 in. shaft 1 ft long = 380 lb × 1 ft = 380 lb
Wt 10 in. shaft 1 ft long = 264 lb × 3¼ ft = 858 lb
Wt 10 in. shaft 1 ft long = 264 lb × 2½ ft = 660 lb

Wt of shaft = 9,680 lb

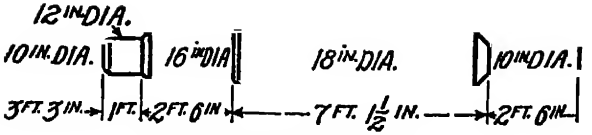

Fig 16—Shaft Dimensions

Example

find the weight of a cast iron ring 11 ft outside diameter, 1½ ft face × 1 ft thick (see Fig. 17):

RULE.—Diameter × 3 = circumference or distance around ring (nearly).

450 lb = wt of 1 cu ft cast iron.
10 ft × 3 = 30 ft circumference.
30 ft × 1½ × 1 = 45 cu ft.
45 cu ft × 450 lb, cu ft = 20,250 lb.

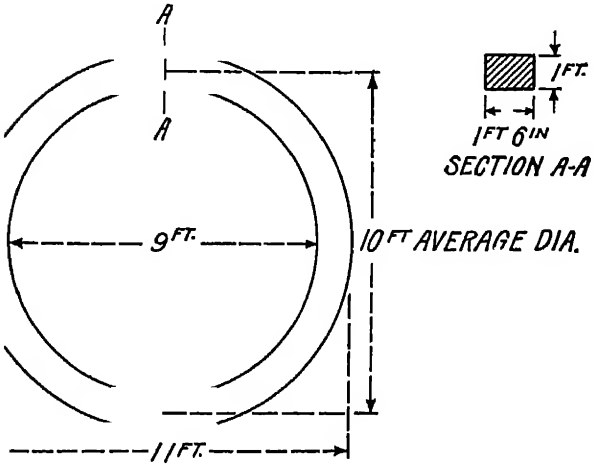

Fig. 17—Field Ring Dimensions.

Example

The simplest way to find the weight of a steel casting is to find the weight of center section separate from the flanges. (See Fig. 18.)

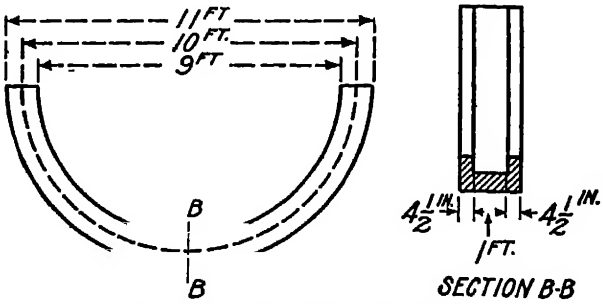

Fig. 18—Field Ring Dimensions

Average diameter of center section, 10½ ft.
10½ ft × 3 = 31½ ft circumference.
31½ × 1 × ½ = 15¾ cu ft in whole ring, 7⅞ cu ft in half ring.

Flange diameters are 11 ft and 9 ft with an average diameter of 10 ft. As there are two flanges of same size, they would be equal to one flange having an average diameter of 10 ft, with a thickness of 4½ in. or ⅜ ft.

Then 10 ft × 3 = 30 ft circumference.
30 ft × 1 × ⅜ = 11¼ cu ft in both half flanges.
7⅞ cu ft + 11¼ cu ft = 19⅛ cu ft.
490 lb × 19⅛ = 9371¼ lb weight of casting.

The clove or double half hitch, shown in Fig. 19, is very useful in the hands of a trained rigger, but, except for hauling, should not be generally used where other slings are available.

The black wall hitch, shown in Fig. 21, is exceedingly useful where material is to be drawn along the floor, for hauling cars on a level, where hitch is to be made quickly, or where a change is frequently required.

Fig 19 — Clove or Double Half Hitch

Fig. 21—Blackwall Hitch.

Fig. 20—Clove or Double Half Hitch—Method of Making.

Fig. 22—Bowline Knot, First Position

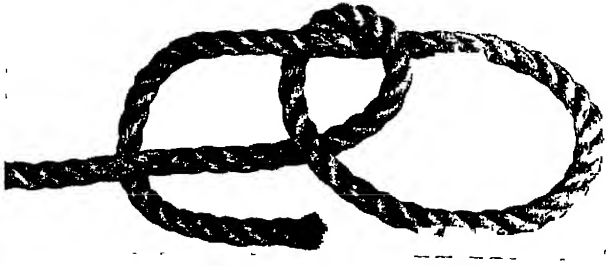

Fig 23—Bowline Knot, Second Position

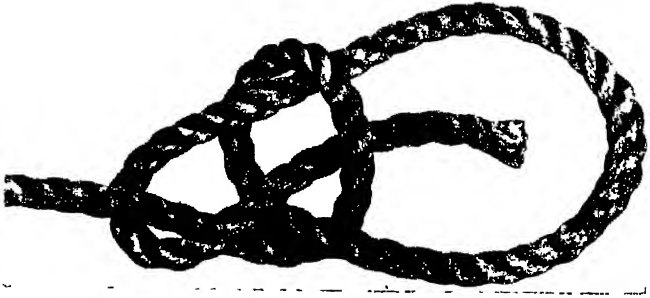

Fig. 24—Bowline Knot, Third Position—Complete Knot Cannot Slip.

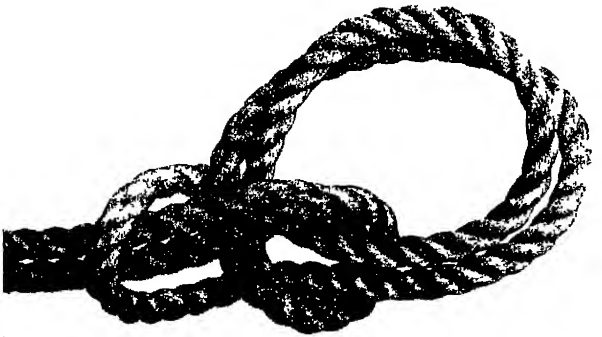

Fig 25—Bowline on a Bight

The "bight" of a rope is the doubled part, illustrated in Fig. 25. There should be very little use for the knot outside of the Riggers' Department.

The knot shown in Fig. 26 generally is used for an adjustable sling. It can be adjusted quickly, and is safe and useful in the hands of trained riggers.

Fig. 26—Sheet Bend in Bye.

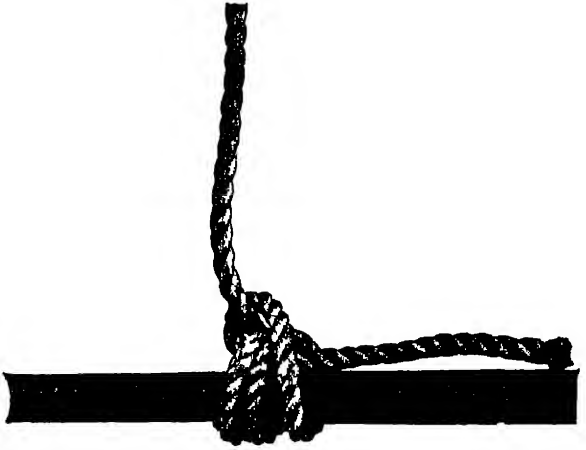

Fig 27—Studding Sail Hitch—May Be Used for Hoisting Timber or Such Material

Fig. 28—Timber Hitch—Used Principally for Hoisting Rough Lumber.

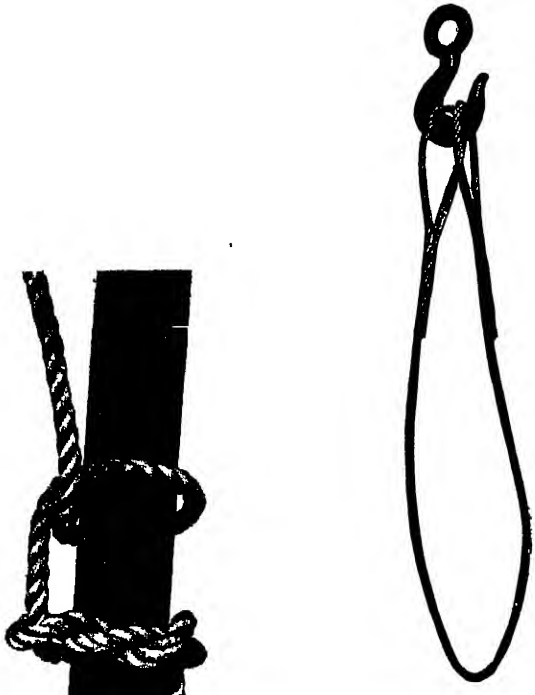

Fig. 30 — Wire Cable Sling — Proper Way of Using with a Hook.

Fig. 29—Timber and Half Hitch—Useful for Hoisting Shafts or Timbers in a Vertical Position.

Fig 31—Double Cable Sling Correctly Used—Pads Should Be Used on All Sharp Corners to Protect Cable.

Fig. 32 — Another Method of Protecting Cable on Sharp Corners Is by Means of Corner Blocks Shown

Fig 33—Right Way of Making a Hitch—the Friction of the Cable Around the Object, Giving Approximately a Two Part Cable on Each Sling

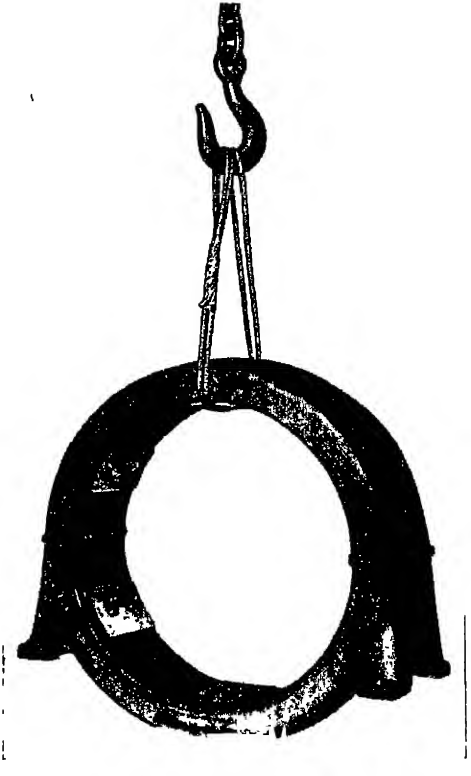

Fig 34—Hitch with One Cable Sling

A sling used as shown in Fig. 34 permits of a slight slippage that equalizes or gives an equal pull on each part of the sling.

In lifting work of the nature shown in Fig. 35 the angle of the slings should never be less than 45 deg. The manner of making hitch to be as shown.

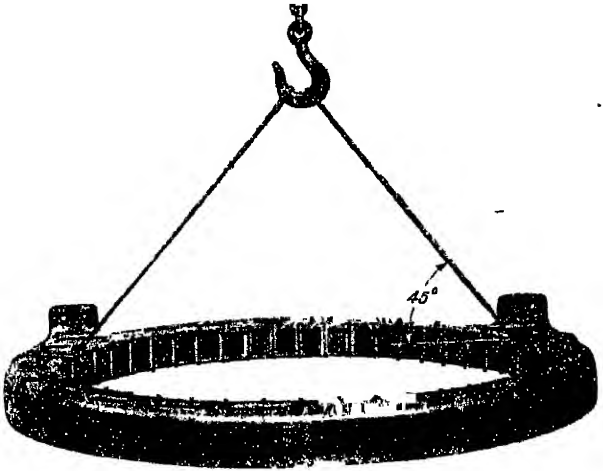

Fig 35—A 45 Degree Angle Sling.

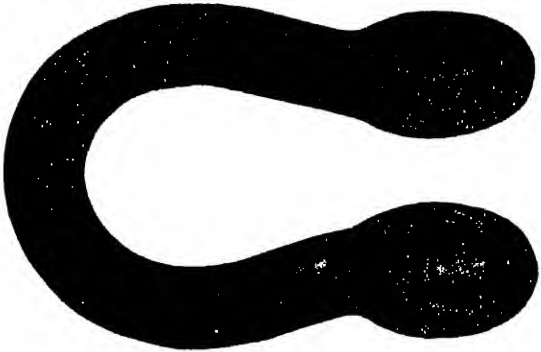

Fig. 36—Shackle.

The shackle shown in Fig. 36 is used where a bolt can be passed through the shackle and a hole or opening in the part to be lifted.

Fig. 37—Double Hook

For lifting flat disks or flanged pieces where hook can be properly applied the double hook illustrated in Fig. 37 is employed. These hooks should never be used on inside of hole or bore of any casting where they might slip, and the use of three hooks equally spaced is preferable.

When lifting revolving field, as shown in Fig. 40, two or more double slings should be used, depending upon the weight, the slings to be placed behind two adjacent arms and protected by means of padding.

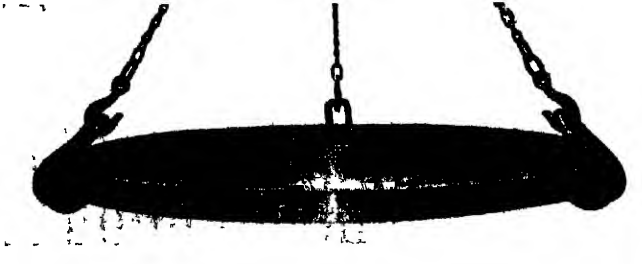

Fig. 38—Three Double Hooks—Where Possible Use in Preference to Two Double Hooks

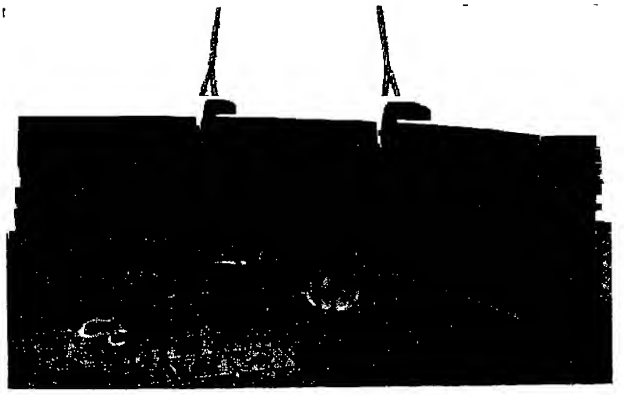

Fig. 39—Set Screw Clamp Hooks for Heavy Work.

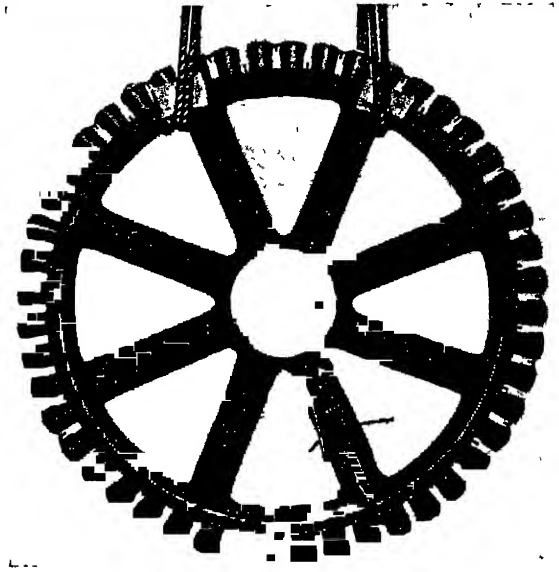

Fig 40—Lifting Revolving Field.

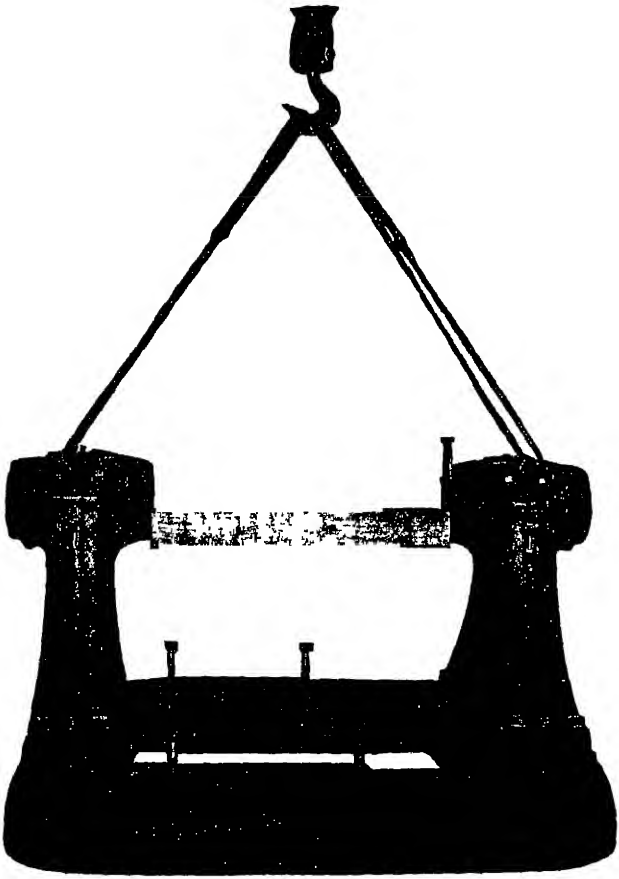

Fig. 41—Lifting Base with Bearing Standards.

Frequently a base and standard are lifted and no provision is made for any lateral strains that may occur,

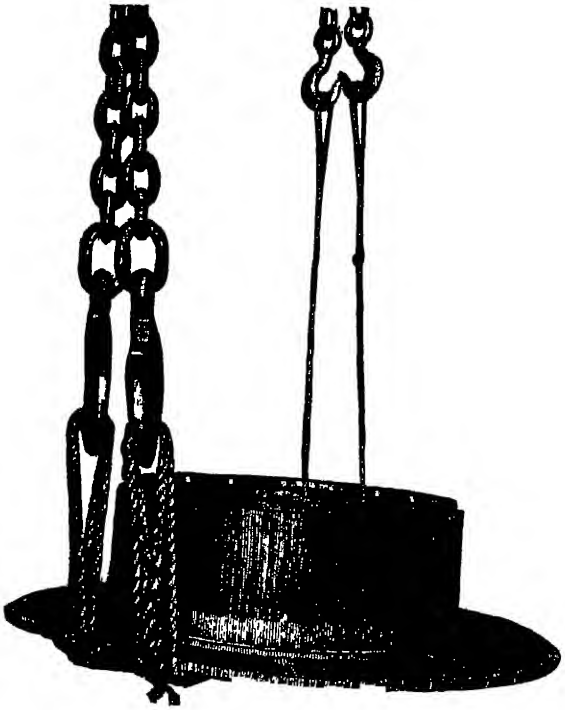

Fig. 42—Turning Over Commutator, Position 1

placing an unnecessary strain on the bolts fastening the standards to the base. When such a lift is made, a piece of timber should be placed between the bearings to relieve the strain, as shown in Fig. 41.

In turning over a commutator wire cable is passed up around two or more arms to hooks on auxiliary hoist, while manila rope slings pass down around two or more arms and up outside to main hoist, as shown in Fig. 42.

To turn commutator over, both hoists are used to lift work high enough to clear floor. Auxiliary is then held

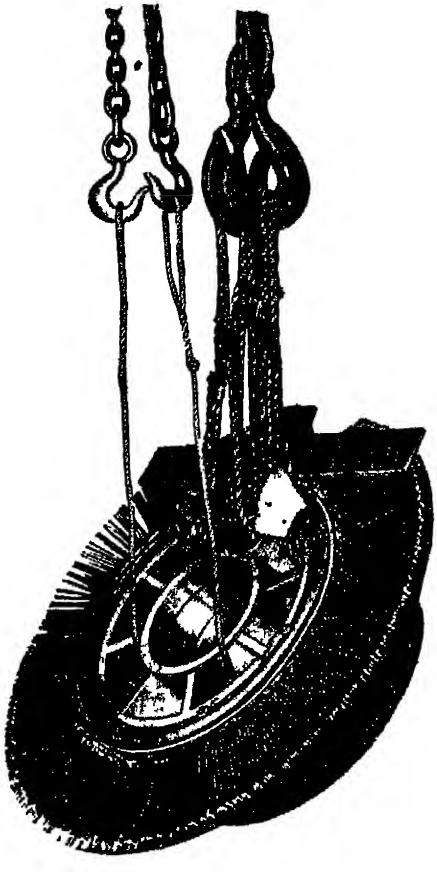

Fig. 43—Turning Over Commutator, Position 2.

stationary, while main hoist continues to raise one side of the commutator until it hangs, as in second position illustrated in Fig. 43.

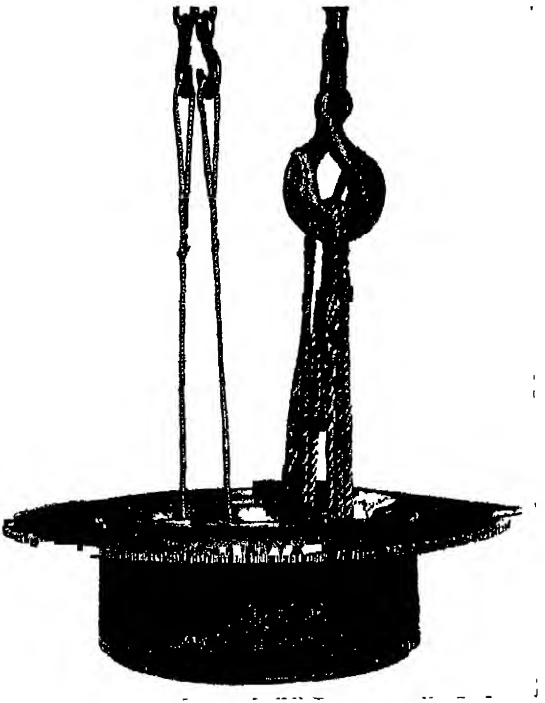

Fig. 44—Turning Over Commutator, Position 3

The commutator having been turned to the position shown in Fig. 43, operation is completed by changing wire cable and lowering on main hoist until commutator hangs level as in Fig. 44.

As shown in Fig. 44, the commutator is turned completely over and ready to be lowered to the floor or table Great care must be used on a job of this kind. Enough pads and blocking should be used at all times to give ample protection to commutator and slings.

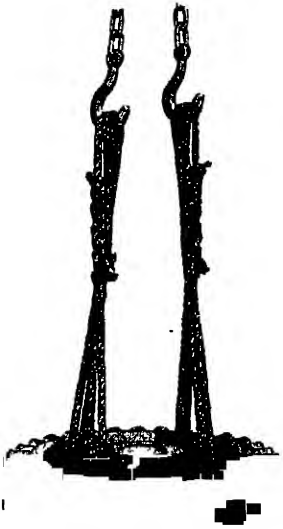

Fig 45—Turning Over Revolving Field, Position 1.

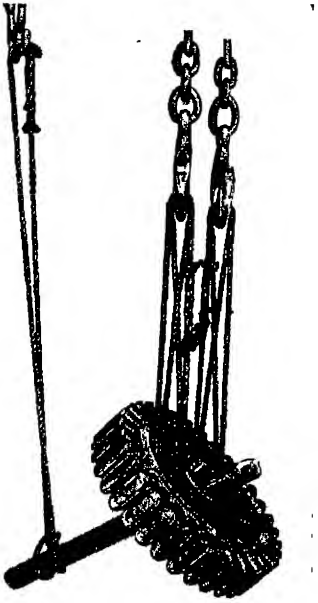

Fig 46—Turning Over Revolving Field, Position 2

When turning over a revolving field a double set of slings should be used on main hoist to lift field high enough for turning, using padding wherever necessary. (See Fig. 45.)

The field having been hoisted high enough for turning, a suitable piece of timber should be placed through bore of field, outer end of timber being raised by sling connected to "small hoist." (See Fig. 46.) By lifting on small "hoist" and lowering on "main hoist" work is turned over. Great care should be used, especially against chafing or cutting of slings.

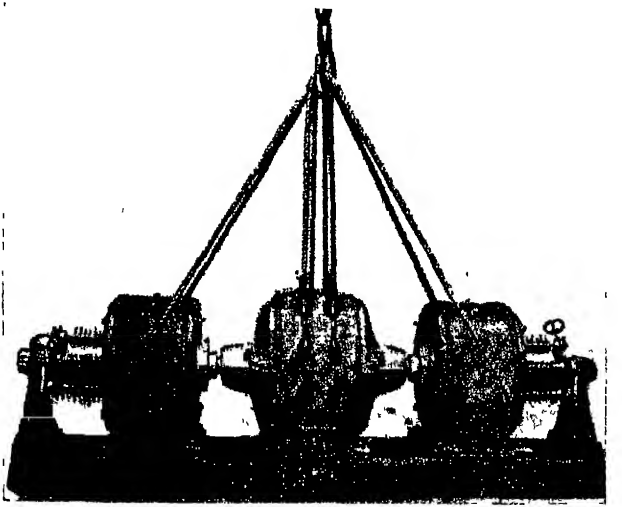

Fig 47—Lifting Motor Generator Set.

The hitch shown in Fig. 47 for lifting motor generator sets consists of two slings with hooks attached to both ends of each. For usual work slings are of equal length, one sling being bent around shield flange on frame to left, ends passing over crane hook and then ends of slings fastened in holes to right in middle frame.

In lifting 90 tons by two cranes, one of 60 tons and the other of 30 tons capacity, equalizer hooks should be located so as to bring center of weight one-third of beam's length away from end attached to 60-ton crane.

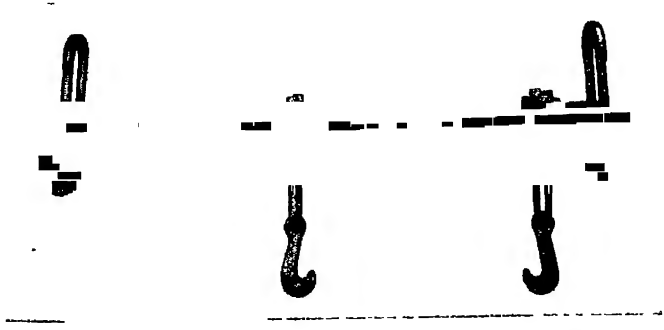

Fig 48—Crane Equalizer, Used with Two Cranes of Different Capacities for Lifting More Than Safe Capacity of One Crane.

(See Fig. 48.) This puts two-thirds of weight on 60-ton crane and one-third on 30-ton crane.

The crane equalizer with geared adjuster, shown in Fig. 49, has a very sensitive adjustment, enabling shaft or any other part to be lifted on exact plane desired.

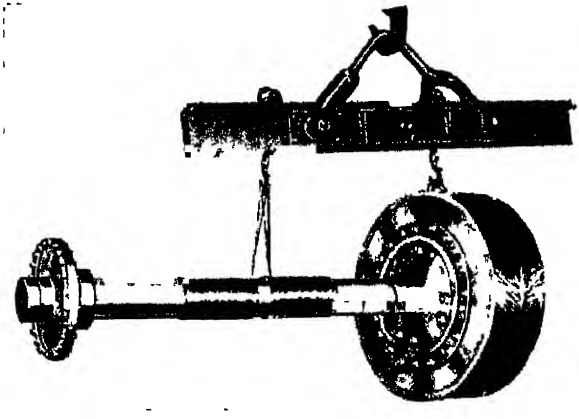

Fig. 49—Crane Equalizer with Geared Adjuster.

Fig 50—Large Stator

In turning over large work such as stator shown in Fig. 50, slings must be allowed to slide in order to equalize strains imposed by changed position. Roller device below allows sling to slide without chafing. Two soft brass castings are used on outside of stator, while hooked-shaped brackets are used on inside. Brackets are of steel, each having three rollers.

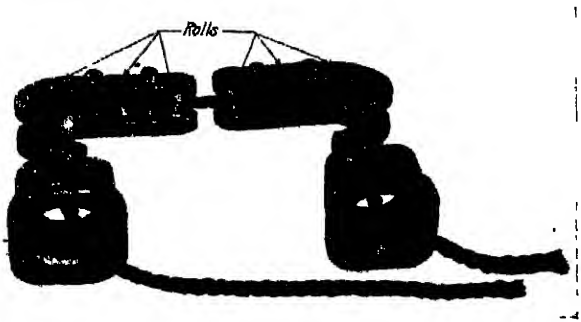

Fig 51—Guides and Rolls for Cable Used on Heavy Work.

Section XXXII
STATION WORK, PRIOR TO ENERGIZING

I. Occurrence of Accidents

Analysis of a large number of accidents indicates that the greater number, though not necessarily most serious, of construction accidents, occur during early stages of work, before system voltage is applied.

Contributing causes are congestion, haste, movement of heavy apparatus over temporary floors, confusion, inadequate protection. Later in the course of the work this order, with its consequent hazard, is eliminated.

Emphasis is accordingly directed to the need of orderly processes of construction. Allowance of adequate time in schedules by obtaining executive authorization to proceed early, carefully detailed advance progress schedules, delivery of materials on short headway before actual need, frequent house-cleaning and constant vigilance produce order and safety.

II. Hazards and Precautions Based on Actual Accidents

Work	*Hazard*	*Prevention*
Demolition.	Falling materials.	Vigilance of crew in danger area.
	Nail puncture.	Remove immediately all nails.
	Flying dust and particles.	Box chutes.
	Trips and falls.	Remove débris immediately.
Clearing.	Falling trees.	Keep clear.
	Axe and adze cuts.	Proper use of tools.
Drilling.	Air or steam pressure.	Relief valve inspection.
Blasting.	Flying rock.	Mats. Logs. Warnings.
	Premature explosion.	Careful handling by experienced men only.

Work	*Hazard*	*Prevention*
Excavating.	Cave-ins.	Piling. Shoring.
	Dropped material.	Keep clear of shovel or bucket.
Tunnelling.	Flooding. Bends.	Air locks. Pressure rooms.
Piling.	Loss of control in unloading.	Snub rope.
	Crushing while handling.	Guy rope. Keep clear while canting.
Duct excavation.	Cave-ins.	Piling. Shoring.
	Unprotected walkways.	Guards. Light.
	Unsafe barrow runways.	Firm construction.
Cribbing.	Falling rock.	Keep clear.
	Swinging derrick chains.	Keep clear.
Driving piles.	Drop weight while placing.	Pin weight in place.
Falsework, bridges.	Falls.	Nets or staging.
Cutting rock or concrete.	Mushroomed drills.	Tool inspection.
	Misdirected sledges.	Tongs and gloves.
	Flying particles.	Goggles and screen.
Steel framing.	Improper attachment.	Use experienced rigger.
	Defective slings.	Use experienced rigger.
	Crushed fingers.	Care in placing.
	Dropped rivets.	Screens.
Concrete forms.	Lumber loosely piled.	Pile carefully.
	Slivers.	Gloves.
	Edged tools.	Gloves and proper use and protection when carried.

Work	*Hazard*	*Prevention*
Mixing concrete.	Falling materials.	Keep clear.
	Dropped barrows.	Proper walkways.
Stripping forms.	Nails and slivers.	Remove immediately.
	Falling boards.	Remove immediately.
Masonry walls.	Falling bricks, tools, etc.	Scaffold toe-boards.
Cutting steel.	Incandescent particles.	Keep clear.
Piping, steam and water.	Falling pieces.	Experienced riggers.
Iron conduit handling.	Sharp or ragged threads.	Gloves.
	Carrying in congested places.	Leave aisles. Two men carry.
	Dropping or falling pipe.	Don't stand on end.
		Pile carefully or stack in alternate horizontal layers.
Conduit bending.	Broken bender shoes.	Tool inspection.
	Thread slivers.	Gloves.
	Improper position-strains.	Proper method.
Conduit templets.	Edged tools.	Protect edges. Proper use.
Cable reels.	Tripping, rolling.	Chocks, blocks, jacks.
Cable reel lagging.	Nails exposed.	Drive back points.
Blowing out duct.	Dust particles.	Goggles or warning.
Snaking.	Tripping over snake.	Remove from paths.
Cable pulling.	Rope or cable break.	Prevent excess tension.

Work	*Hazard*	*Prevention*
Attaching pothead.	Lost control-pinches.	Sufficient help. Blocks. Care.
Lead wiping.	Firepot. Flames. Flying solder.	Shields. Pothooks. Care on ladders. Signals for manholes. Dry out pots, ladles. Use goggles.
Cutting insulation.	Edged tools.	Cut away from self.
Insulating compounds.	Fires. Hot fluids.	Guards. Care on ladders.
Moving apparatus.	(See Section XXI Rigging.)	
Unboxing.	Nails. Slivers.	Gloves. Drive out nails.
Painting and finishing walls.	Scaffolds, ladders, etc.	(See Section II. Tools.)

Section XXXIII

STATION WORK—INITIAL ENERGIZING

It appears, from examination of N E L A and other records, that the consideration of this subject has been inadequate, and it would seem pertinent that suggestions for safe methods can be matters of direct recommendations by Accident Prevention Committee.

I. Check of Circuits

When electrical construction work has progressed to the point when lines or equipment may be energized by the closing of switching devices, they should be tagged with a holdoff and reported to Load Dispatcher, System Operator or other authorized person, and not put into service except with his express permission.

All electrical circuits, control wiring, main circuits, etc., should be thoroughly inspected under supervision of staff

in charge of plant operation or those directly in charge of placing in operation and making alive, in order that all concerned may become familiar with the various circuits, their sources of energy, delivery of energy and control. Comparison of drawings and wiring diagrams should be made, and the checking of electrical connections should, if possible, be made by non-associated parties, and the results of their inspections reported for approval to authority in charge of energizing the apparatus or circuits.

II. Live Test of Control Circuits

All temporary grounding connections should be removed and permanent grounds inspected and, where necessary, tested to determine their condition for proper functioning. All control and supervisory circuits should especially be checked, if possible, by actual electrical operation, before energizing the apparatus which they control, in order to assure no accidental or wrong connection of apparatus and circuits with other apparatus or circuits already energized, and to assure positive functioning and control of the apparatus which they supervise or control.

III. Relay Settings and Test

Relay settings should be pre-determined, and the lowest value of setting permissible under test or operation used. It is advisable, to assure a safe control of circuits or apparatus, that the relays be tested by means of artificial load to assure their proper operation. If possible, test load should closely approximate actual full load conditions, and settings thereafter remain as checked.

IV. Warnings and Guards, Designations of Apparatus (See N E S C Handbook No. 6, Rule 119)

All permanent and temporary warning signs, danger signs, temporary guards and apparatus lettering and numbering should be placed where needed before putting apparatus or equipment into service. Reliable persons should be stationed at points where necessary to warn

employes or others upon the premises of hazardous conditions that may temporarily or permanently exist. Proper notification of the energizing operation should be given to all concerned. It is well, when possible, to limit persons present to those actually engaged in the energizing, at least for preliminary tests, because too many unnecessary spectators cause confusion and may incur risk if anything goes wrong.

V. Final Inspection for Tools, etc.

Thorough inspection should be made to ascertain that tools, wiring materials and miscellaneous construction conditions are cleared away before apparatus or circuits are energized.

VI. Temporary Test Circuits

All temporary wiring or testing circuits should be safely installed, properly guarded and designated, and should be removed as soon as possible, after completion of tests.

VII. Insulation Tests

Tests in accordance with standard practices should be made in order to determine condition of insulation of apparatus and wiring.

VIII. Acceptance Test Wiring

Wiring for acceptance tests should be carefully planned in advance and installed with care for safety equivalent to that accorded to permanent installation.

IX. Gradual Increase of Operating Voltage

If possible, it is advisable that all circuits and apparatus be energized gradually from zero voltage to normal voltage, or a 10 per cent overvoltage over a sufficiently long time interval to permit frequent and careful inspection for defects or other conditions of hazard.

X. Switching

Important switching operations, executed in connection with new apparatus, should, if possible, be done

under the supervision of two competent operators, after each has agreed as to the proper movement or control of circuits, apparatus or circuit breakers. Such schedule should be carefully analyzed, and a written schedule prepared in advance. The actual operations should be performed only after it has been ascertained that they will create no hazardous or unsafe condition beyond the normal functioning of the apparatus or circuits in question.

XI. Extra Supervision

Where practical, extra supervision should be given or the regular starting or operating forces should be augmented for sufficient length of time in the care and handling of new apparatus, in order that frequent inspection may be made. In case of accident or failure of apparatus, sufficient help will then be available to properly meet the needs of the situation.

XII. Full Operation and Short Circuit Test

When possible, tests under full operating conditions, also including single phase and polyphase short circuits, reversal of power, etc., will give the most conclusive evidence of the correctness and selectivity of relay settings, wiring, and adjustment of mechanisms. The behavior of apparatus under abnormal conditions, which may be encountered in operation, will then be definitely known. Finding defects in test may prevent operating failures and resulting accidents.

XIII. Organization of Operating Crew

When any generating or substation approaches completion, the operating crews should be selected and organized early enough to give them sufficient opportunity to familiarize themselves with the plant and their duties prior to starting up. This length of time will vary with the complexity of the system.

XIV. Fire Protection during Starting (See N E S C, Rule No. 106)

Special fire protection is desirable at time of initial

starting and tests. This should consist of portable pressure tetrachloride types of extinguishers for fires having an electrical hazard of live apparatus, and foam types for large area oil fires without electrical hazard. Experienced fire guards should be at hand.

Section XXXIV
STATION WORK—ALTERATIONS

From time to time, as the demand on the electric generating station or substation increases, or the installation of new and improved apparatus seems advisable, it is necessary to proceed with additions to or substitution for existing equipment, and at the same time keep the station in operation. Work under such circumstances calls for the greatest care, especially where congested and dangerous conditions exist, which characterize many of the older installations. Work of this nature should be done only by careful and experienced men, and those under the supervision of one thoroughly familiar with the layout of the apparatus and connections.

The following recommendations are made for the avoidance of accidents to workmen or property in doing work of the above class.

I. Carrying Material

Lengths of material, such as pipes or bus bars in excess of 6 ft, should be carried around live apparatus by two men, one at each end, to insure against accidentally swinging against and short circuiting live parts, or causing electric shock to the workmen. There is also a danger of swinging against or catching on switch handles, or mechanism causing same to close or to trip out. Keep material off shoulders.

II. Barricading Exposed Live Parts

Wherever possible, temporary barricades should be erected and live parts carrying high voltages should be barriered, using fireproof or fire-resisting materials,

while the work is in progress, and danger signs posted at these points as an additional warning. Rubber blankets and rubber linemen's shields can be used to advantage when working in close proximity to dangerous parts, or near voltages within the proper limits of protection afforded by such means. A S T M Standard Specifications D120-23 and D178-24 for Rubber Gloves and Rubber Matting are based on working limits of 3,000 v to ground.

III. Moving Apparatus

When moving bulky apparatus around, a careful survey should be made of the path over which it is to be moved to assure plenty of clearance from live projections and to make provisions for safeguarding against them.

IV. Light (See N E S C, Rule 103)

It is very important to provide plenty of light behind switchboards or in dark corners or basements where work is being carried on. Flexible cord extensions or portable lights should be avoided, as far as possible, since they are in themselves a hazard when being dragged around in the vicinity of high voltage equipment. However, if they must be used they should be made of extra good quality cord or rubber insulation and have non-metallic guards and handles. Temporary lights of a stable nature should be installed wherever required, and the wiring for same kept at a safe distance from possible contact with high voltage parts.

Glare from exposed brilliant light sources should be avoided, as it tends to diminish rather than aid vision. (See Bulletin 331, U. S. Bureau of Labor Statistics, and A E S C No. A-11, Code of Lighting Factories, Mills and Other Work Places.)

V. Identification of Cables

All wires and cables involved in the work of carrying out alterations should be carefully traced out and tagged for identification (see N E S C Rule 411E), and where

temporary "jumpers" are used, these should be properly insulated, installed in a careful and workmanlike manner and also tagged for identification. When possible, a check by two men is desirable.

On large systems temporary connections should be installed with safety precaution equal to that necessary for permanent installation.

VI. Work near High Voltage Apparatus

A man should not work alone where there is danger of accidentally coming in contact with high voltage parts. A second man should be assigned to assist him and be on the lookout to warn him if in danger. (See N E S C Rule 411B and E, 432F.) The second man should be on the alert to observe any dangerous conditions or failure to use necessary precautions, and warn his working companion should he get into dangerous proximity to live parts. It is well to interchange the functions of men so paired, in order to prevent the duties of observer from being discharged in a perfunctory way. Work should not be done above live unprotected equipment. (See Section III, Clearances.)

VII. Clearing Floors

Only such material as is actually required for immediate use should be allowed to take up floor space in congested places, and parts which are permanently removed should not be allowed to litter up the floors, but should be taken away as soon as possible. As far as is feasible, remove apparatus from crates or packing cases before taking to the job, so as not to litter up the floor around the work with boards and packing material. Floors should be swept as frequently as necessary to keep clean.

VIII. Holdoff and Tagging

In changing responsibility over equipment, necessitating holdoffs of circuits or apparatus, the station rules in this respect must be strictly observed. (See Section IV, Holdoffs.)

IX. Tools

Tools should be neatly arranged where readily available. These should not be scattered around where, besides creating a tripping hazard, time and efficiency is lost in seeking them when required. (See Section II, Tools.)

Snakes, metal tapes, cloth tapes or rope handlines, reinforced by metal, are especially hazardous, and use should be prohibited in live stations. (See N E S C, Rule 422A5.)

X. Rigging and Handling

See Section XXXI, Rigging and Handling.

XI. Protective Grounds

See Section V, Test Provisions and Protective Grounds.

XII. Ionizing Agents

Since the existence of ionized gas containing metallic vapor constitutes a serious short circuit hazard in high voltage stations in operation, great care should be used to prevent its production in sections with live open current carrying parts. Some ionizing agents are arc lights, oxy-acetylene flames, etc. Gauze screens will not segregate the ionized gas if an arc exists, since the ionizing will proceed in the gas beyond the screen, in any area which the direct rays from the arc may reach.

XIII. Flashlights for Photography

After station is energized, flashlight photographs with use of magnesia powder should be prohibited, as the smoke vapor is a conducting gas.

Section XXXV

INSPECTION, REPAIRS, MAINTENANCE, EMERGENCIES

I. Conditions of Work

The greater part of inspection and repair is carried on in live operating stations. By whatever group this work is performed, its safety depends on close coopera-

tion with the operating crew. The first essential is an effective holdoff system. (See Section IV, Holdoffs.) Holdoff system should insure: (a) initial killing of circuit; (b) inviolability of holdoff; (c) mechanical lock and block out of protecting circuit breaker; (d) check when possible of correctness of switching and blocking.

Provision should be made for temporary safety grounds as recommended by Accident Prevention Committee Serial Report, "Temporary Safety Grounding" (N E L A Publication No. 278-4).

Some maintenance and inspection details are done with machines in operation. Foremen or men in charge must take special precautions, particularly with commutator machines and rotating parts, and in passages, bus compartments, etc. (See N E S C, Rule 430B, C, D.) Handrails, footways, guards, shields and like protection should be used. (See N E S C Rule 114. See Section III, Barriers.) Foremen should personally point out to each man the safe limits of his working area. (See N E S C Rule 421.)

II. Emergency Repairs

After short circuits, fires, explosions, disruptions, etc., emergency forces are called in by operators. In such occasions more than ordinary precaution and thoroughly experienced men are required. Among the hazards and precautions are:

Holdoff and Tagging System is again extremely important.

Telephone facilities should be kept available for sole use of those in charge of emergency work. Instructions received on the telephone should be written down and read back to the party giving them to assure accuracy and eliminate misunderstanding.

Care should be taken to clear premises of unauthorized persons and all whose presence is not needed in work of cleaning up. Definite responsibility for taking charge in emergency should be fixed on a prop-

erly established organization, which shall include properly trained assistants ready to assume charge in order of seniority.

Special emphasis is placed on the extremely dangerous and sometimes concealed hazards, among which are:

Hazard	*Precaution*
Disarrangement of wires, or destruction of insulation may prevent the damaged circuits from being completely isolated from current carrying parts.	Use a ground stick and make solid ground on all parts before proceeding. Ground should be applied only with use of a shield. (See "Temporary Safety Grounding," N E L A, Publication No. 278-4.)
Existence of voltage may prevent use of certain fire extinguishers that use conducting fluids.	Emergency force must be thoroughly informed in use of fire extinguishers of various types.
After accidents to oil filled apparatus, there may exist inflammable mixtures of oil vapor and air.	All containers of such possibly inflammable explosive mixtures must be scavenged and ignition of the mixture prevented.
Supports of damaged apparatus may have been weakened. (Example—6 ton reactor insulators were destroyed by short circuit heat.)	See that all heavy suspended or supported members are blocked in position before disturbing damaged parts.
Floods or leaks in buildings in which high voltage exists may cause danger-leakage paths.	Generally necessary to isolate the apparatus which must be worked on to dry out or wipe off.
Damaged parts to be rigged out may not withstand movement.	Special bracing will sometimes be required.

Hazard	*Precaution*
Quick repairs are generally essential. Haste is dangerous.	Use caution. Haste makes waste. Before going to work, a study of the moves to be made and review of connections with system operator will save confusion and time.
Fires often bring in firemen uninformed in handling high voltage.	A "Fire Department" in each station should be organized and drilled in necessary precautions. City fire forces should be prevented from incurring risk, although it must be recognized that if other property is endangered city forces in many cases have the right to exercise supreme authority.
Fumes may cause suffocation.	Use respirators, or gas masks.
Heated metals cause burns.	Use gloves.
Broken porcelains cause cuts.	Use gloves.
Fire extinguisher chemicals are sometimes slippery and cause falls.	Be careful of footings.
Electric arcs for welding and cutting and oxy-acetylene flames are ionizing agents.	Do not use near live high tension buses so as to cause ground path through ionized gas.
Flashlight gas cause of short circuits.	Do not use in operating stations near exposed live conductors.

III. Fire Extinguishers (See N E S C, Rule 106)

Since one of the features of the majority of electrical emergency cases is the extinguishing of fires, some brief consideration of fire-fighting apparatus is desirable.

Good characteristics of portable apparatus are:

(a) Ease of lifting. No excess weight.
(b) Ease of direction of stream. Pressure type affords greatest accuracy at safe distance. Pump type harder to direct accurately.
(c) Non-freeze in cold weather.
(d) Non-stoppage of nozzle.
(e) Non-conductor of electricity.
(f) Non-producer of noxious fumes in close quarters.
(g) Non-corrosive to insulation of windings.
(h) Non-producer of dangerous excess tank pressure.
(i) Simple to operate.
(j) Simple to refill.
(k) Permanence of chemical condition.
(l) Blanketing effect on oil fires rather than scattering by too great force of jet.

Since there are many good types of fire extinguishers on the market, none of which possess all the features mentioned above, the selection of equipment must include several types to meet all conditions. A small carbon tetrachloride type (non-conductor) for incipient electrical fires; a larger carbon tetrachloride pressure type for fires that must be fought from greater distance; a soda acid type (conductor) for non-electrical location; a foam type large capacity for large area fires without electrical hazard or oil fires, is a good selection. (See Section IX.)

PART E—LINES

Section XXXVI

UNDERGROUND LINE WORK

See Section XXXVII, "General."

In metropolitan areas an ever-increasing proportion of service lines are being laid underground. Observance of municipal regulation will materially aid accident prevention.

Work or Hazard	*Precaution*
Danger from automobiles.	Manhole railing guards; station employe guards; place red caution signs broadside to direction of travel; street barriers and lights at night.
Stones thrown by automobiles.	Place excavated dirt as a barrier, and keep street clear of pebbles and stones.
Dust in eyes; infections.	Goggles on windy days.
Chipping asphalt and concrete causes flying particles.	Goggles, shields for pedestrians.
Compressed air tanks.	Experienced engineer or operator. Safety valve inspection.
Trenching and manholes; cave-ins.	Safe piling and side wall bracing.
Blasting operations.	Mats. Experienced men.
Placing duct and concrete.	Safe runways.
Heavy manhole covers.	Use hooks, keep feet and hands clear, Prevent strains.
Rodding-mandrels.	Care not to drop on man in hole.

Work or Hazard	*Precaution*
Pulling cable overstrained.	Watch wire cable tension. Use dynamometer on hard pulls.
Handling reels.	Keep under control, drive back lag nails.
Water from street.	Temporary curb around manhole.
Gas in manholes.	Delay entering manhole. Masks. Forced ventilation. Prohibit flame or lighting matches in manhole. (See NESC Handbook No. 8, Rule C, E.)
Cable identification.	Check by blueprint, air and identification tag. Test for voltage by electroscope. Woodpecker identification.
Spiking cable.	Use remote controlled spiking jack.
Holdoff.	Phoned messages must be double checked to prevent misunderstanding. Most holdoff tagging is done without check by cable foreman.
Jointing. Knife cuts.	Care in use of tools.
Wiping.	Keep lead pots away from manhole openings. Use care in lowering hot lead.
Conductor identification using low voltage currents.	Test currents — cable alive with low voltage. Prevent shorts.
Phasing out in manhole or making live taps and splices. (Cables alive—high voltage.)	Special care in using protectors and gloves and preventing grounds. (See Sec. XXXVII, V. 9.)

I. Trenches. (See Excavations, Section XVII)

1. *Storing Material.* Ducts, paving brick, and dirt should be neatly piled and may be used as a barrier. All street openings should be barricaded for the protection of the workmen as well as the public.

Fig. 52 — Trench Properly Barricaded on Sidewalk and Street.

II. Manholes

1. *Manhole Ladders.* Permanent steel ladders in manholes are recommended wherever possible. They allow the workman more working space, and a quicker and safer means of exit.

2. *Manhole Guards.* Guards should be placed over the manhole when the cover is removed. These guards should be substantially constructed, readily visible and held in place by lugs or short legs extending inside the manhole.

Fig 53—Substantial Type of Manhole Guard.

3. *Fishing Conduits or Ducts.* Do not "fish" conduits or ducts from manhole toward the station. The ducts may be broken, or the conduits may not terminate as indicated, allowing the fish-tape to touch energized equipment.

4. *Inflammable or Toxic Gases.* Various gases in low concentration (hydrogen 4 to 75 per cent; carbon monoxide 13 to 74 per cent; acetylene 2.5 to 82 per cent) may cause burning or even explosions, as well as asphyxiation.

5. *Protection against Gases.* As many gases diffuse rapidly, the most effective protection is thorough air ventilation. A manhole cover has been devised which permits much greater air circulation than older types, thus keeping gas concentrations lower.

Forced ventilation will clear gas before a man enters, but will not insure him against further flow through ducts. It should be continuous for duration of work in the manhole. Helpers at street level should not cease vigilance and frequent communication with man in hole.

Under certain conditions gas masks may be necessary, but they should be used only by men trained in their use. Fresh air masks are simpler and generally safer than self-contained apparatus.

III. Cable Reels

1. *Loading or Unloading Trucks.* Never attempt to lift reels onto trucks. Always use skids for loading or un-

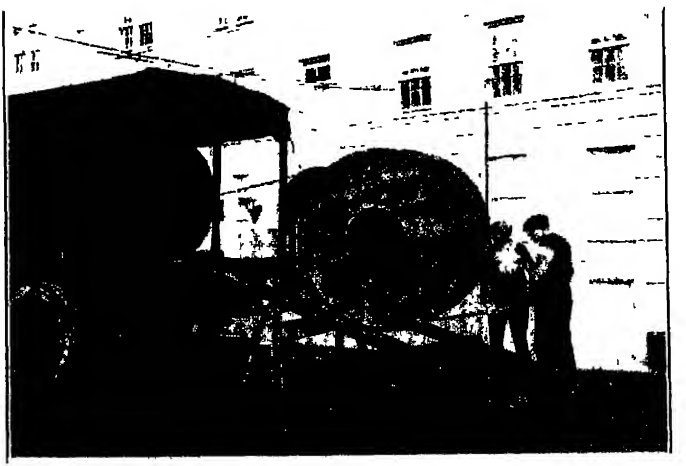

Fig. 54—Correct Method of Loading Reels of Cable.

loading. Stand clear of skids. They may break, or the reel may slip.

2. *Dismantling Reels.* When removing lagging or slats from cable reels, the nails and tin should be immediately removed, and the slats bundled and secured to empty reels. Reels should be securely fastened to poles, or chocked to prevent their rolling around, or, better still, immediately removed from the street. Do not leave them unguarded on grades. Reels left on streets overnight should be guarded by red lights.

IV. Cables

1. *Cable Pulling.* In pulling cable, take precautions against the basket, sheaves, lashing or winch gears slipping. Avoid the danger of having the hands drawn into the tackle by the pulling line. Stand clear of the pulling line when under tension.

2. *Cable Splicing.* When necessary to splice energized cables this work should be done only by experienced men. They should use extreme care and proper safety devices.

3. *Handling Energized Cables.* Climbing in or out of manholes by stepping on cables should be forbidden. High voltage cables should be bent or moved only by experienced cable men.

4. *Handling Tools and Material.* Always use a handline for raising or lowering tools and material. When work is completed, all scrap should be removed. A manhole should never be left in a dirty condition.

5. *Insulation.* The value of insulation as protection from shocks is reduced by the dampness usually found in manholes. The restricted spaces often bring the workman closer to energized equipment than in other kinds of electrical work, and the imperfect illumination also makes special care necessary to avoid contacts. The human body and all surrounding surfaces become more conducting where dampness exists, and electric shocks are therefore more severe.

6. *Safety Equipment.* Rubber blankets, bandages, gloves, sleeves, mats and insulated footstools should be provided. This equipment should comply with A S T M specifications, which are endorsed by the N E L A, and be tested frequently. Instructions regarding their use should be issued and enforced.

Section XXXVII

OVERHEAD LINE WORK

The material of this section is based on the National Electric Safety Code, and the Accident Prevention Course for Linemen, an Accident Prevention Committee publication (N E L A Publication No. 24-36). The latter has been rearranged, abridged, and, to some extent, changed and supplemented with new items. (See National Electrical Safety Code Handbooks 6 and 8.)

I. General

1. *Qualifications for Work.* Foremen should assign only men qualified by experience on work of hazardous nature, unless under continuous supervision and instruction by qualified men. Necessary qualifications for accident prevention are:

a. Self-possession.
b. Courage. (1) Physical. (2) Moral courage to refuse to take unwarranted chances.
c. Judgment. Realization of the dividing line between courage and foolhardiness.
d. Knowledge of job. Familiarity with circuits, hazards, rules, proper use of tools and protection of workers and public.
e. Physical competence, strength, agility, vision, hearing, health, stamina, absence of vertigo, possession of all members.
f. Sobriety.
g. Ability to use and understand correct English.

h. Habit of careful forethought and precise thinking.
i. Obedience.
j. Concentration and application to work.
k. Ability to apply standard prone pressure method of resuscitation.

2. *Repetition of Unwritten Messages.* Since many instructions must be sent by telephone, it is necessary, to avoid misunderstanding, that the sender of message demand and receive the correct repetition of all unwritten instructions. The receiver should satisfy himself as to identity and authority of sender. (See N E S C Handbook No. 8, Rule 420.)

3. *Conditions for Safety.* Before attempting any work, climbing a pole, entering a manhole or vault, thorough inspection for dangerous conditions should be made. Insecure poles, crossed wires, presence of gas in inclosures, bad insulation, etc., present serious hazard. Their presence rather than absence should be assumed. Report permanent conditions of danger to proper authority.

A plan of action with the necessary safety precautions should be detailed before work proceeds. (See N E S C Handbook No. 8, Rule 433.)

4. *Application of Rubber Protection Devices.* Linemen should not depend on others but should personally apply insulating coverings to live lines adjacent to working position. If such insulation has been previously applied by self or others it should be checked on each arrival to working position.

5. *Live Parts.* Lines and equipment, unless positively known to be dead and solidly grounded, should be considered alive. This status should obtain as soon as a wire is drawn over the first cross arm or connected to a piece of apparatus. Both wire and apparatus should be treated as alive.

6. *Talking.* Superfluous conversation may distract attention, thereby causing accident, and should, therefore, be prevented.

7. *Horseplay.* Work ordinarily safe may become dangerous through horseplay. No condemnation of this can be too severe, nor punishment too drastic for practical jokers in electrical work.

8. *Clothes.* Should be appropriate and neat without loose ends, straps, metal buttons and clasps which offer hazard. Rings, jewelry and keychains should be discarded while on job. Shoes should have sewed, not nailed, soles. Hats and ear caps should contain no metal. (See N E S C, Rule 420H.)

II. Site of Work

1. *Streets.* Place barriers and warning signs so that traffic will be properly directed away from manholes, trenches, poles being erected, trees being pruned, wires, guys, cable reels or other obstructions in street.

2. *Generating or Substation Yards.* Inspect premises for lightning arrestors, transformer banks, signal wires or other equipment in service adjacent to working space, which may offer hazard of exposed current-carrying parts.

3. *Railway Right of Way.* All guys, wires, handlines, materials, tools, etc., must be kept clear of track. Suction of passing trains must be guarded against.

Foremen should keep posted as to train schedules and watch for approach of trains.

4. *Clearing Right of Way.* Hazards are present, such as loose footings on steep hillsides, rock slides, underbrush, falling branches or trees. Axe and saw wounds sustained at locations remote from skilled medical attendance may require first aid. Blasting requires experienced men in storing, transporting, handling, loading and firing of explosives.

III. Poles

1. *Carting.* Where poles are carted so that one end of the pole projects beyond the rig, an indicator should be placed at the rear end of the pole to warn traffic and

pedestrians of the projection. In the daytime this indicator should be a red flag or sign, and at night a red lantern should be used.

2. *Temporary Storage.* Where poles are stored temporarily in roadways before erection or removal, they should be placed as close as possible to the curb or edge of the roadway. They should not be stored at points in the road where there are sharp turns. Each pole should be placed so that its top (smaller end) faces the direction of traffic. Poles stored on highways should not have cross arms or steps attached.

Poles temporarily stored in roadways should be marked at night by means of lamps or other means at the disposal of the company, in order to avoid possible accidents.

3. *Pole Setting.* Where it is necessary to blast in excavating for a pole location, every precaution must be taken in the handling of dynamite and in protecting at the surface by mats against flying pieces of rock and dirt. All men in the gang must be kept clear of the blast and all traffic must be guarded.

When it is necessary to keep pole holes open over night in a district where pedestrians pass, each hole should be properly barricaded or covered. At least one red light of sufficient power to warn passers-by should be displayed. Care should be taken so that the barricade or covering itself does not have projecting nails or any other feature which might injure pedestrians.

When the erection of a pole requires that it be laid across a highway so as to obstruct traffic in both directions, two men should be assigned to guard and warn traffic on the highway while this danger exists; each man to guard one direction of traffic, and to be stationed at least 100 ft away from the pole being erected (See N E S C, Rules 421H and 433H.)

Where poles are raised by means of derricks and gin poles, linemen and groundhands should avoid standing

close to the derrick, gin pole or the pole being raised, whenever the work in hand does not require that they remain in this position, so as to avoid possible injury in case the pole should fall.

4. *Piking.* When poles are piked the men should handle the pikes firmly so that they will not cut-out and fall on other workmen. All work in the operation of piking poles should be done under the direction of and following the signals from the man in charge.

5. *Back-filling.* When pikes are used to hold a pole while the back-filling is being tamped, they should be firmly grounded in all directions when necessary to prevent the pole from falling. Pikes should not be removed until the back-filling is sufficient to hold.

After a pole has been set, all obstructions to traffic must be removed before the gang handling the pole-setting moves away.

6. *Inspection.* (See N E S C, Rule 433.) Before a lineman attempts to climb a pole, he should make sure that it is strong enough to carry him safely. Poles which are decayed or badly raked must be securely guyed or else braced before a lineman attempts to climb. Where pole-butts cannot be inspected for decay, as in the case of poles set in concrete pavements, poles should be securely guyed or braced before the lineman ascends.

7. *Bracing.* On pole replacement or pole removal work, no pole should be climbed for the purpose of clearing it of all wires and cables until it has been first guyed or else braced securely to offset any change in strain which may be caused by the removal of these wires and cables.

In connection with the removal of poles, guys should not be removed until all temporary supports have been securely located. Temporary supports are taken to mean pikes, digging bars, rope, block and tackle, rope guy lines, and so forth.

8. *Removal.* All members of the crew who are not actually engaged in the removal of poles should stand

clear so as to avoid possible injury in case of the pole falling. All pedestrian traffic and all highway traffic, where necessary, should be stopped in both directions while a pole is being removed.

9. *Climbing.* Before a lineman climbs he must first find out the position of all high voltage wires and the direction of feeds. He must determine the best climbing space, especially at junction poles. In choosing a climbing space, it is desirable, if possible, to climb on the sidewalk side up to a point just below the lowest gain. (See N E S C, Rule 433.)

In choosing climbing space, every effort must be made to avoid ground wires, where they are located on the poles being climbed. Wherever possible, it is desirable to have ground wires on the opposite side from that part of the pole chosen for climbing.

Weather checks, knots, shakes, rots and hard places should be avoided to prevent the cutting-out of the spurs. For the same reason tin signs, nails and tacks should be avoided while climbing. All unauthorized tags, signs and advertising display cards on poles should be removed.

In climbing, a lineman should avoid standing on mail boxes, fire alarm boxes, pole telephone boxes and similar foreign equipment which may be attached to the pole or located near it.

Where steps are provided they should be used in every case. As a lineman climbs up a pole having steps, he should try each step before trusting his weight upon it. Steps which are bent should be avoided, even though they appear secure. (The hook on all pole steps should be maintained pointing up.)

Where a coating of ice covers the pole, the pole steps or any part or all of them, special care must be taken in climbing up and down the pole. Where climbers are used, care must be taken to prevent spurs from cutting-out. Where steps are used, care must be taken to avoid slipping.

When more than one man is climbing up or down

a pole at the same time, the second lineman, going up or down the pole, should allow the first man sufficient time to avoid spurring, or other conflicts with the first lineman. It is preferable that only one lineman descend at a time.

Where a pole is leaning or raked, a lineman should use the upper side wherever possible, so that in case the pole should fall the lineman will have a better chance to jump and there will not be as much chance of the pole falling on him. The pole should be braced.

Where steps are not provided, climbers should be used by lineman in coming down a wood pole. Except in unusual emergencies, a lineman should not jump from a pole, slide down a pole or guy wire or attempt to "coast" from the working position to near the ground level before using his spurs.

10. *Support.* The safety belt should never be put around that part of a pole above the top cross arm when the latter is located close to the top of the pole. (See N E S C, Rule 420J.)

Double arms are preferable to single arms for support. Never put belt around end of cross arm, as it might slip off. Insulator pins and braces should never be used as support. The safety belt must never be put around any member of the structure that is being removed.

11. *Unloading.* Very serious accidents have occurred in unloading poles from flat cars. Several companies are using a method of unloading by means of rope slings, which is quick and safe. Inspection of stakes and binding wire is the first precaution. Special car stakes are placed on the back side of the load, and these stakes are braced to the ground by use of substantial timbers set at 45 deg angle and well up on the car stake. These are used to support the back (opposite to unloading) side of the loads when the load binding shall have been cut. Two and one-half inch (2½ in.) ropes, of one hundred fifteen feet (115 ft) length each, are made fast

at one end to stake sockets on the unloading side of the car, one near each end. These ropes are thrown over the top of the load and a turn taken around the hub or journal box of the car trucks and around couplers. The unloading skids are then put in place as usual. Next, the binding wires and stakes on the unloading side of the car may be cut safely (using long-handle wire cutters), the two ropes holding the load back against the braced stakes on the back side of the car. Next, the men standing at the back side of the car and clear of the ends of load pay out the ropes, braking by the turns around the journals and couplers, allowing the load to settle easily down on the unloading skids. (See illustrations, pages 765 and 766, N E L A Proceedings, Vol. 84, 1927.)

IV. Pole Accessories

1. *Installation.* Before raising cross arms or drilled materials aloft all dimensions should be checked and other materials, such as insulators, should be inspected If circuits cannot be killed, adequate portable insulation should be securely placed on live circuits before raising metal arms and parts. Hand lines must be thoroughly secured and the lashing tested before raising parts aloft. If braces are attached to a cross arm to be raised, the free ends of braces must be lashed in to the cross arm. All men not actually engaged in raising material should stand clear. Those engaged should watch the piece until it is secured in place aloft. Street and sidewalk guards and barriers should be placed, so that traffic cannot come within the danger zone. Only one piece should be raised at a time.

Small materials and tools should not be thrown up to men working aloft or dropped by them, but should be raised or lowered in insulated canvas bucket or with hand line. Tools and materials should not be stored on cross arms but in canvas bags. Only dry hand lines should be used.

2. *Insulator Pins.* If attached to cross arm before raising, care is required to prevent fouling wires.

3. *Insulators.* Insulators should not be installed on pins until immediately before wires are to be attached, and should not be left loosely on pins but screwed down tightly at once.

Guy strain insulators should always be used to insulate working positions on wood poles from ground potential. Line and side guys, whose upper part is liable to be made alive by contact with falling high tension wires, should be equipped with guy strain insulators so that street and highway traffic coming in contact with lower parts of the guy will be fully protected. Head guys should be equipped for protection of working positions. Guy strain insulators should be set in guy wires at a height of at least 8 ft from ground.

4. *Hardware.* Hardware should not be stored or transported in containers used for rubber goods or gloves, insulators, linemen's belts or climbers, because injuries by the hardware to the rubber goods may indirectly lead to accident. Hardware transported in same truck with linemen should be housed securely to prevent shifting or being thrown on linemen.

In replacing hardware, no piece should be removed if weakening of pole or cross arm supports will be caused.

Through bolts, if too long, should be cut and sharp edges of cut filed.

V. Wires

1. *Roadway and Jointly Occupied Lines.* Wires should be strung and maintained so as to clear the roadway by an amount not less than that specified by the governing rules or conditions. Wires and guys which are being strung should be kept clear of the roadway. Where it is necessary to block the roadway temporarily while wires and guys are being installed, one or more members of the gang should be assigned to guard traffic in one or both directions, as may be necessary.

Where linemen are working on jointly occupied poles, or where linemen are working on a line which crosses the line of another company, the linemen should take every proper precaution to prevent material and equipment from coming into contact with the second line while this material or equipment is being raised or lowered. They should also prevent wires, guys, messengers or cables which they are pulling up or cutting from coming into contact with parts of the second line.

Every effort must be made not to interfere with the operation and maintenance of the second line.

2. *Inspection.* Before a lineman undertakes any work on a pole, tower or structure, he should first make a complete inspection from the ground of the position of all high voltage wires and find out the direction of feed in each case. He should determine the best and safest climbing space, especially in the case of wooden junction poles.

He should determine the necessary amount and kind of portable protective insulation which is required and should take this material from the truck and inspect it carefully before he attempts to climb into the high voltage wires.

Each time a safety belt is used, a lineman should test it by applying his weight against the safety so as to make sure that the safety belt is in good condition, and that the snaps are securely fastened to the "D" rings and that there is no chance that the snaps will cut-out while the safety belt is being used. While a lineman is making this test he should support himself with both hands in case the safety should fail. (See N E S C, Rule 420J.)

3. *Climbing Space.* (See N E S C, Rules 236 and 237.) Climbing space should not be used for temporary or permanent wires, fixtures or attachments. It should be kept clear at all times for free passage of linemen and material.

4. *Protection.* Weatherproof covering on line wires should not be depended upon for protection, as it has

little, if any, insulating quality, which weather conditions may destroy completely. Often weatherproof covering will appear to be in good condition when it is actually in very poor condition.

All high tension wires near the working position should be protected with portable protective insulation, where the voltage of these wires will permit working in safety with this portable insulation. Nearby wires should be taken to include all adjacent line wires, laterals, taps and risers.

In those cases where the voltage is so high that portable protective insulation cannot adequately protect workmen, the lines, taps, laterals and risers located near the working position and carrying this high voltage should be "killed," discharged to ground and grounded on all sides of the working position before any work is undertaken.

When it is necessary to work on energized circuits it can be safely accomplished with the use of approved "power-on" tools in the hands of trained men under careful supervision, and with limitations as to kind of work.

Except in those cases where full protection can otherwise be provided, only one lineman should be allowed to climb a pole before the portable protective insulation is installed.

In placing portable protective insulation for the working position the lineman should first apply this insulation to the parts nearest at hand and then continue to apply the insulation progressively outward in all directions until the most distant part requiring insulation has been protected. This process of application is used in order to protect the lineman from contact with the nearest parts. **Rubber gloves should always be worn while portable protective insulation is being installed.**

In the removal of portable protective insulation from wires and equipment the reverse order should be maintained. That is, a lineman should remove the most distant piece of insulation first, and remove the nearest

piece of insulation last, in such a way that he will be at all times protected. **Rubber gloves should be worn at all times while portable protective insulation is being removed.**

The use of such portable protective devices provides an insulating barrier between the lineman and energized wires and equipment adjacent to his working position, thus minimizing the possibility of contact with live parts through body movements while in the working position. It must be understood that the use of portable protective insulation does not in any way permit dispensing with the use of rubber gloves. A lineman must always use his rubber gloves while working on energized circuits of a voltage for which the gloves are applicable.

Where it is necessary to do two or more jobs in one working position, only one job should be undertaken at a time. For instance: Suppose that it is necessary to cut two taps into a 2300-v line to supply 2300-v single-phase energy to another point in the system. In that case, the first tap should be made with all other adjacent wires fully protected with portable protective insulation. When the first tap has been tied in and insulated it should be covered at all points with portable protective insulation before the point on the second wire where the second tap will be made is uncovered. (See N E S C, Rule 433.)

Where "dead" wires are located near the working position, they should be considered as being alive at full voltage unless they are effectively grounded at a point near the working position.

Only in rare instances is it necessary to stand on transformer cases, pole type line voltage regulators or constant current street lighting transformers. On account of the danger due to the grounded cases, insecure footing, etc., the necessity of taking such a working position should be prohibited except by special permission of the foreman, who should direct the placing of protective rubber goods. For equipment mounted on wood poles, rub-

ber mats should cover the cases, and lineman should use care that his spurs do not touch the mat. It is not necessary to use mats on cases mounted on grounded steel poles. Linemen should not stand on cases without fastening safety belt to pole.

On wood poles all wires at ground voltage in the working space should be covered with protective insulation whenever any other conductors in the working space are also covered with portable protective insulation. On grounded steel towers it is not necessary to provide protective insulation for wires at ground voltage in the working space.

5. *Working Position.* A lineman should wear his rubber gloves at all times while working on high tension wires at voltages for which the gloves will give full protection. In wet weather a lineman should wear his rubber gloves while he is working on secondary circuits whenever he is so instructed by his foreman. Some companies require gloves to be worn even on low voltage live circuits. This is advisable, in view of the growing recognition of the seriousness of low voltage shock.

A lineman should never lean over or crowd through unprotected wires. He should always attach his safety belt, and place himself in such a position that, if he falls as a result of electric shock or slipping, he will swing clear of live wires. Such an accident might result from disengagement of one snap of his safety or from his spurs cutting-out.

Whenever possible a lineman should work on wires from below. (See N E S C, Rule 422G.)

A lineman should not move backward against wires or equipment that may be alive.

A lineman should do one thing at a time and should keep his eyes on his work at all times.

When a lineman is working on live wires or equipment he should never allow any part of his body to come close to any live or grounded parts other than those that are properly protected.

When a lineman is close to high tension lines or equipment he should avoid touching ground wires, guy wires, span wires, metal pipes, metal conduits, metal poles, metal sheaths, signal wires, signal equipment, transformer cases, transformer hangers, street lighting fixtures and other metal parts, which may be grounded.

When a lineman is in contact with communication lines or equipment, metal sheaths, metal pipes, metal conduits, ground wires or metal fixtures on poles, he should avoid coming close to high tension lines or equipment, guys or span wires.

Where it is necessary for a lineman to walk out on cross arms, the wires of which are covered with blankets, line protectors or other type of portable insulation, he should take particular care that his spurs do not touch the insulation.

Lineman should not work on poles above other workmen except in case of emergency or when it is unavoidable, and then only when extra precautions are taken. Where linemen are working at two or more levels on a pole or tower, the linemen working at the lower level should be prepared at all times to step aside when they are working in the climbing space, so as to permit the men working at the upper level free use of the climbing space. Men working in the climbing space on the lower level should always stand clear while material and tools are being raised to and lowered from the upper level. The groundhand assigned to the raising and lowering of material should not begin to raise or lower until all linemen on the lower working level have signalled that they are clear of the climbing space.

Tools and small material required at the working space should be stored in an insulated tool bag when not being used. Large tools and material which cannot be easily stored in tool bag should be kept in the truck when not actually being used aloft.

6. *Stringing Wires.* In stringing wires, care must be taken not to put kinks into any part. Kinks reduce the

strength of the wire and may result in fallen wires later.

In the handling and stringing of weatherproof covered wires, care must be taken not to injure the weatherproof covering.

A lineman should not change the strains on a pole by adding wires until he is satisfied that the pole will safely stand the altered strains.

If possible to prevent it, wires which are being strung should not be allowed to sag so as to come close to the sidewalk, street or highway. Where these wires may interfere with sidewalk and highway traffic, at least one watchman should be assigned to guard the street and highway in one or both directions, as may be necessary, and wherever wires may sag while being pulled. (See N E S C, Rule 433J.)

While a lineman is stringing wire on a wood pole, he should avoid coming in contact with all ground wires, messengers, sheaths of cable, metal pipes, metal conduits, guys, lighting fixtures, span wires, signal lines, signal equipment and other attachments which may be at or near ground potential. Where it is necessary to string wires near live lines, dry hand lines or other suitable means should be provided and used Rubber gloves should always be worn.

Where there is a possibility that the wire being strung may come into contact with live wires, the lineman should assume that the wires being strung are at the same voltage as the wires of the live line, and he should protect the wires being strung in the same way that he protects the live wires. (See "Temporary Safety Grounding," N E L A Publication No. 278-4.)

7. *Splicing.* Where rubber gloves are worn in making a splice in wires they should always be worn when insulation is being put over the splice. Pliers only should be used to bend wires into the splice.

While a splice is being soldered, solder catchers should be used to prevent molten solder from falling and striking other employes below or on the ground, as well as

persons on the street or highway below. All persons should be kept away from the base of the pole while solder is being raised or lowered. A splice should be dry before solder is applied. Solder should be dried before it is placed in a hot pot.

In making a splice, care should be taken to make it as strong as the line wire to prevent later breaks and fallen wires.

8. *Tying-In Wires.* Wires should be tied in at all insulators securely so as to prevent the possibility of wires becoming loose at points of support and possibly falling to the ground. Where double arms are provided, line wires should be well tied in to insulators on each arm. This applies to pin type insulator work.

9. *Tying In.* Where it is necessary to tie in two parallel circuits which are connected at one or more points on the line, the several phase wires should be tested for identification with a potential transformer or other means so as to make sure that the phase wires of one circuit are being connected to the corresponding phase wire of the other circuit, to prevent short circuit.

Where it is necessary to tie in two lines connected with different sources of energy, as for instance tying-in line, connected with Station A and line connected with Station B, at least one line should be made dead while the splice is being made unless means are available at the splicing point to test for phase rotation and to synchronize one line with another before they are connected.

10. *Grounding.* No high tension lines should be approached and no grounding attempted by linemen until satisfactory arrangements have been made for killing and holdoff, so that the lines at the point in question may be grounded. A lineman should test the line with a "hot stick" before attaching grounds as a check that line has been killed. All possible points of misunderstanding should first be cleared before work of this character is undertaken.

Where a line or part of a line has been "killed" and grounded, a lineman should make sure before he touches any of the wires that the protective grounds have been placed between all sources of power and the point at which the work is being done.

Where there are other lines on the same or on nearby poles in the same general direction, there is always a possibility that the section of line about to be worked on may not be at ground voltage either due to induced voltage or accidental contact. Special care should be taken in those cases to place local grounds on each side of the section being worked on to secure positive protection against accidental shock.

All circuits connected to the grounded wires to be worked on should be checked for apparatus which is liable to operate after service has been disconnected. Such apparatus should be disconnected, locked and blocked, and the connecting circuits grounded to avoid a possible feed-back from this source.

11. *Placing Grounds.* The grounding device should first be attached to a good ground connection supplied for the purpose, and the other end of the grounding device should then be attached securely to the wires or equipment to be grounded (by the use of proper ground attaching sticks).

It is the opinion of the Accident Prevention Committee that positive clamp and flexible cable is generally preferable to ground chains. However, when ground chains are used they should be first inspected for condition as to freedom from oil, dirt, etc. Chain which does not make a low resistance connection should not be used. In applying grounding chains, they should be tightened well when they are being installed. Dry hand lines should always be used in installing ground chains. Where there is more than one circuit on a pole it may be impossible to safely apply ground chains, and in those cases ground clamps or other grounding equipment should be used.

Where it is necessary to ground lines having a weatherproof covering, special provision should be made for this work, to secure good ground connection without undergoing hazard while removing covering.

12. *Removing Grounds.* The removal of grounds should be handled in the reverse order to that used in placing the grounds in position, that is, that end of the ground wire attached to the line wire or equipment should be removed first and then the other end, connected to the ground, should be removed.

13. *Cutting.* A lineman should never change the strains on a pole by removing wires until he is sure that the pole will safely stand the altered strain. Where a pole will be weakened by the removal of the wires it should be guyed as may be necessary before these wires are removed.

Before a lineman cuts a wire aloft he should make sure how it will fall. Where a falling wire may touch live lines, suitable dry hand lines or other means should be used in lowering it.

Lines which are being cut or rearranged should not be allowed to sag so that they will fall directly on, or be blown against: other lines, communication lines or equipment, metal sheaths of cables, metal pipes, ground wires, metal fixtures on poles, guy wires, span wires.

Wires which have been cut or which are being rearranged should not be allowed to fall near or on roadway where there is danger to traffic. Where it is impossible to keep these wires safely clear of the roadway, depending upon the voltage of the adjacent lines, all street and highway traffic should be guarded in one or both directions as may be necessary. All employes working on lower levels of poles where the cutting is taking place and all employes on the ground should be notified well in advance of the cutting so that they may stand clear.

14. *Fallen Wires.* (See N E S C, Rule 421H.) It

should be the duty of all employes to watch for fallen wires. When an employe finds a fallen wire carrying a high voltage in a more or less congested district, he should stand by it so as to protect all street and highway traffic from it. He should, as soon as possible, instruct some available bystander to telephone to headquarters to either have the wire "killed" or to have it raised from the ground. This employe should not leave the fallen wire until he has been so instructed by the official in direct charge of the fallen wire.

15. *Fire.* All lines close to a fire should, where necessary, be cut "dead" immediately to protect the firemen fighting the fire. They should not be made alive again until all danger has been removed. Where lines are located close to a fire, the lines should be inspected carefully, the insulators should be inspected for cracks, and the cross arms and poles should be inspected for charring, before the lines are restored to service.

16. *Street lighting wires,* unless grounded, should be considered alive at all times. The voltage of street lighting circuits should be considered as being that of the highest voltage wires occupying one or more poles on which the street lighting circuit is run, in those cases where this voltage is in excess of the street lighting voltage. This is necessary, in view of the fact that sometimes street lighting wires become crossed with high tension wires during the day when not in use.

17. *Secondary Circuits—Street Lighting.* Careful attention to the following considerations will reduce the hazards of street lighting circuits.

A. *Multiple.* It is recommended that multiple street lighting transformer secondaries be grounded in accordance with usual practice.

B. *Series.* Serious hazards exist on the series circuits due to opening of secondaries, through burn out of lamps, breakage of wires, etc. In such cases the open circuit voltages build up to high values. If lights are out, repairmen or others might assume that circuit is

dead and get across gap. If overhead wires should break in such a manner that one end contacts with ground and the other dangles in air, pedestrians may complete the circuit. Various relay schemes have been suggested to open primary circuits or short circuit secondaries in such cases. Most of these schemes have serious defects. The simplest and thus far best scheme for all purposes seems to be the film cut-out. The necessity of frequent inspections and tests for accidental grounds, crossed wires, etc., is of prime importance in eliminating hazards. It is felt that to place intentional grounds would increase hazards.

18. *Foreign Wire Attachments,* such as communication lines and equipment, and so forth, should be considered alive and should be avoided at all times, unless otherwise protected. While a lineman is working on poles he should be careful not to disturb foreign lines and equipment which may be attached to the same pole.

19. *Installation of Ground Wires.* (See N E S C, Rule 239.) Ground wires should, when practicable, be installed clear of all line equipment which may be designed to be insulated from ground, such as cross arm braces, through bolts, pole steps, transformer cases, street lighting fixtures, etc.

Ground wires on wood poles should be protected, when necessary (see N E S C, Rule 283), by a suitable guy plate, to prevent the guy wire from cutting into the weatherproof covering on the ground wire and to prevent the pole end of the guy wire from becoming grounded.

Ground wires should be protected with molding of approved type throughout the entire effective working length of the pole and also for such a distance above the ground as regulations may require (See exceptions, N E S C, Rule 239.)

20. *Guy Wires.* Insulators should be connected into the guy wire line before the guy wire is set in place. Rubber gloves should not be worn while the insulated guy line is being made up.

21. *Installation of Guy Wires.* N E S C, Rules 282 and 283 set forth clearance and strength requirements for guy wires and insulators. In new work, guys should generally be installed before line wires are strung. In reconstruction work guys should be installed before any changes are made in the line wires, and care must be taken not to place excessive pulls on the pole and wires already in position.

Guys should be so installed as not to interfere any more than necessary with the climbing space and should clear all high tension wires as far as practicable.

Guy strain insulators should be provided wherever necessary to secure the required amount of protection, except as provided in N E S C, Rules 282 and 283.

Guys should be carefully installed on poles to prevent them from becoming loose. Where necessary a lag screw, a through bolt or hook may be used to prevent the guy from slipping down the pole. These screws and bolts should not interfere with climbing and should be so placed that they will not be used as steps. Where guys are liable to cut into the surface of a pole, the pole should be protected at the point where the guy is attached by a guy plate. The plate must be well secured to the pole to prevent the possibility of injury to a lineman climbing up or down the pole.

All guys which are anchored should be installed so that the guy does not interfere with street or highway traffic. Where these guys are located near street or highway they should be equipped with traffic guards conspicuously painted or marked so that they can be the more readily seen at night. (Traffic guards are sometimes called "anchor shields.")

In installing a guy wire, the guy must not be allowed to come into contact with or pass close to live wires on the pole. Where such a condition may arise, a dry hand line should be used.

Guy wire should be so installed that it will not rub

against any messenger or communication cable carried under supply lines.

Guy wire containing snarls or kinks should not be used for line work. Guy wires should not contain any more splices than absolutely necessary. Standard guy clamps or other positive clamping devices should be used in making all stiff steel guy wire splices.

Guys should not generally be attached to trees, but when this is necessary the condition of the tree should be examined carefully before guys are attached. Guys should be attached to only sound and stiff trees or limbs of trees.

Wherever necessary guys should be held from trees by means of tree blocks. Where guys are anchored to trees, provision must be made for tree growth.

22. *Removal of Guys.* Before wires and guys are removed, the condition of the pole at the ground line must be determined. If the butt of the pole is found to be weak, it should be securely braced before any changes in pole strain are made.

Where the removal of wires from a pole will so change the strain as to present a dangerous condition the pole should be braced temporarily to make such changed condition safe.

Where it is not possible to install side guys, buck-stayed guys may be necessary. Buck-stay guyed poles are sometimes called "self-supporting" poles. The buck-stay should be so installed that it will not interfere with climbing and it will not interfere with street or highway traffic. Buck-stayed guys should not be used in connection with climbing.

VI. Transformers

1. *Installation.* All frames and tackle used in the erection of pole type transformers should be carefully inspected each time before they are used. Defects should be repaired satisfactorily before the frames and tackle are used.

Wherever possible junction poles, subsidiary poles and

street lighting poles should not be used as transformer poles. Where conditions are such that it is necessary to install transformers on junction poles, subsidiary poles and street lighting poles, special care must be taken to maintain proper climbing space and to avoid crowding of wires and equipment.

Transformers should be installed on poles only after the pole has been determined by check to be strong enough to carry their added weight.

When tranformers are raised or lowered, all men of the gang should stand clear and traffic should be guarded. In congested traffic, the pole space should be roped off. Men on the pole should place themselves on the opposite side from that on which the transformer is being raised or lowered.

Double cross arms should be provided for each transformer installation.

Where transformers are installed, the climbing space should be carefully maintained so that it will not be necessary for a lineman in climbing up or down a pole to come close to the transformer case.

2. *Connection.* Pole type transformers should not be connected in circuit unless they are supplied with a sufficient amount of good quality oil.

Where pole type transformers are replaced, the new transformers should be checked for phase rotation carefully before service is restored, so that the new service conditions will be the same as before the change. This is particularly important where the service load consists of elevators and some types of power machinery where a change in motor rotation might cause a serious accident.

In the installation of a distribution type transformer on the line, the primary leads should first be connected to the primary cutouts; second, one side of each primary cutout should be connected to each line wire; third, the secondary leads should be connected to the secondary line; fourth, when all necessary tests have been made, the primary plugs should be installed in the cutouts.

Before transformers are connected permanently to the line, polarity tests should be made so as to make sure that the transformers are connected properly.

3. *Inspection Tests and Maintenance.* Only qualified and authorized linemen and trouble men should be allowed to climb poles to inspect and test pole type transformers and equipment. After taking oil samples drain plugs should be tightly replaced to prevent leaks.

All temporary leads used in testing, such as secondary leads of potential transformers, thermometer leads and recording voltmeter leads, should be securely supported on the pole and should clear all traffic. The position of these leads should not interfere with the climbing space or with maintenance work which may be required while the testing is in progress.

The transformer windings should be completely disconnected from line on both sides, that is, primary and secondary, before the oil is changed. Where it is impracticable to disconnect the low voltage secondary which is not then alive, the secondary side may be effectively grounded in preference to disconnecting. Transformer oil should not be allowed to come into contact with rubber gloves and rubber goods.

4. *Fusing.* The placing or replacing of fuses on the high tension side of pole type transformers should be done only by qualified linemen and trouble men. In phasing out a transformer or in testing it for polarity lamps should preferably be used.

In replacing fuses, a lineman should be careful to avoid contact with live lines, grounded lines, the casing of transformers, street lighting fixtures, signal lines, signal equipment, the metal sheathing of cable, metal conduits, metal pipes, span wires, trolley feeders and similar lines, fixtures and equipment.

In replacing fuses and in installing fuses in new cutouts, a lineman should shield his eyes as far as possible with one arm against possible flashes of the fuse. Linemen's glasses having frame of insulating material and

Calabra Lenses are desirable for this work. In this type of work he should take a firm stand on the pole and have his safety belt well secured so that he will not be liable to slip and fall if a flash occurs. Insulated tongs should be used for inserting or removing primary plugs.

5. *Substations.* Where it is necessary for linemen to work on outdoor substation transformers, each lineman should fully acquaint himself with all the operating rules applying at that substation before he undertakes any work. He should ask for holdoff on the equipment he wishes to work on. He should follow out all instructions of the substation operator and he should report to the substation operator when he has finished his work.

6. *Protection.* All linemen working on or near transformers or parts of transformer circuits, such as fuses, high tension taps, and so forth, should wear rubber gloves and safety belts.

It is very often customary to install lightning arresters and lightning arrester ground wires on transformer poles. While a lineman is working on poles which are furnished with lightning arresters and lightning arrester ground wires, he should be careful to avoid touching the lightning arrester equipment and he should avoid coming into contact with the ground wire.

VII. Street Lighting Fixtures

1. *Installation.* Lighting fixtures should be hung clear of the climbing space and clear of foreign interference. All bolts, lag screws and other hardware used in securing the fixtures to poles should be carefully trimmed to prevent accidents to linemen climbing up and down the poles.

The leads connecting the series street lighting circuit to the street lighting unit should be held securely away from the pole and away from the climbing space. The slack in the leads should be so arranged that they will not be blown into other supply lines or into communication lines or equipment.

Each street lighting unit should be provided with a suitable cutout or absolute cutout to permit of the removal of the lighting unit without opening the series street lighting circuit. (See *Wires*, Paragraph 17, for notes on protection against high voltage due to open secondaries of series transformers.)

Street lighting units, globes and reflectors should be securely installed, so that there will be no danger of their falling into the roadway.

2. *Clearance.* Lighting fixtures should be hung clear of the roadway, so as not to interfere with traffic.

3. *Inspection, Maintenance and Cleaning.* Street lighting line wires and street lighting fixture wires should always be considered alive unless they are held off effectively from all sources of energy, and unless all are effectively grounded.

Where ladders are used to clean street lamps, they should be securely fastened to the pole before they are put in use. Ladders should be so located that they will not interfere with traffic.

Where trucks with elevated or elevating platforms are used to maintain street lighting units, these platforms should be provided with insulated floors so that linemen, trouble men and cleaners will not be liable to shock while they are maintaining the units.

4. *Testing.* The regular testing of street lighting circuits for open circuits, short circuits and grounds should be undertaken at a regular hour each day when linemen will be clear of these circuits.

5. *Protection.* All linemen and trouble men engaged in street lighting work of any description should always wear rubber gloves. Where it is necessary to climb poles, the working position on the pole should be protected as outlined above.

VIII. Equipment

1. *Air Break Switches.* The handles of air break switch levers should be effectively connected with ground

by means of a ground wire, so as to fully protect the lineman or other authorized person operating the switch. (See Temporary Safety Grounding, N E L A Publication No. 278-4.)

The hinges of air break switches should be sufficiently stiff (and maintained so at all times) so that when the blades have been turned into the open position there will not be any tendency for them to fall back on live clips. The switch should be inspected from the ground, platform or other safe place, after it has been opened, to see that all blades have opened a proper distance.

Where single-throw air break switches are opened, they should be opened to the maximum amount.

Double-throw air break switches should be opened so that the blades clear both sides of the switch by an equal amount.

Provision should be made in every case for the locking of air break switches whenever it may be necessary. Space should be allowed for the attachment of several locks at one time.

2. *Horn Gap Switches.* After lightning arresters have been charged, the horn gap switches forming part of the lightning arrester circuit should be opened to normal running position immediately. Where horn gap switches are allowed to remain closed, in the charging position, serious injury may result.

Horn gap switches should be fully opened and completely separated from all live lines and equipment whenever it is necessary to work near the lightning arrester.

3. *Lightning Arrester Equipment.* Where circuit voltages are of such value that rubber gloves will not give sufficient protection, pole type lightning arresters should never be touched or approached unless they are completely disconnected from all live lines and live equipment, and are effectively connected to ground at the line side of the arrester.

Larger types of lightning arresters (such as aluminum

cell and oxide film types) should never be touched or approached unless they are completely disconnected from all lines and live equipment, and unless all parts have been discharged to ground and effectively grounded They should always be provided with screens or fences which will prevent possible contact while parts of these arresters may be alive. The screen or fence should be provided with a gate large enough to permit of the removal of individual units. The gate should be provided with a lock, the key of which should be kept by an authorized person. Gates and fences should be designed to prevent climbing.

4. *Choke Coils.* Choke coils should never be approached or touched unless they are disconnected from all live lines and equipment, and unless they have been discharged to ground and grounded.

5. *Disconnect and Sectionalizing Switches.* Disconnect switches may be used with care to open a live line, but not under load.

Disconnect and sectionalizing switches should be used to sectionalize dead lines where these lines parallel in close proximity other high tension lines, for long distances, because under these conditions large induced voltages may occur.

Disconnect switches designed for the purpose may be used to open a tie line or to break two high tension lines, operated in electrical parallel, or multiple.

Two or more high tension lines connected separately with two or more generating systems should not be connected by disconnect switches on the line, unless means are provided for synchronizing these several lines.

6. *Fuses.* Where fuses are taken out of circuit, they should be removed entirely from the fuse boxes.

A lineman should always shield his eyes when he is installing or removing fuses.

7. *Oil Circuit Breakers.* Where an oil circuit breaker

case is not permanently and effectively grounded, it should be considered alive until the breaker is disconnected from the circuit and all parts are grounded. (See N E S C Handbook 6, Rule 107.)

Oil circuit breaker cases should not be removed from their mountings unless the whole switch has been removed from service and is thoroughly and effectively grounded and protected by holdoff.

Where an oil circuit breaker is removed from service and grounded, the grounds should be so placed that they will not be disturbed or removed during the time that the breaker is disconnected from service.

Oil circuit breakers used for line work should be so provided that it may be possible to entirely remove the handles or to lock the handles in the open position whenever necessary. Space should be allowed for the attachment of several locks at one time, so that separate gangs may be protected. Multiple locks are unnecessary when operation of breaker is under the supervision of a system operator. In that case holdoff tags only are necessary.

8. *Current Transformers.* (See N E S C Handbook 6, Section 14.) The secondary circuits of current transformers must be connected to ground at all times while the transformers are in service.

The secondary circuits of current transformers should never be opened. Where it is necessary to remove any parts of the secondary circuits, these parts should be provided with jumpers before the circuit is disturbed, to avoid the opening of circuits.

No parts of current transformers should be approached or touched unless these transformers are completely disconnected from circuit and effectively grounded.

9. *Potential Transformers.* A "dead" lamp connected on the low voltage side of a potential transformer should not be considered as a positive indication of the condition of the high voltage side. Voltmeters, in addition to lamps, should also be connected to the low voltage

side. Lamps should first be connected in circuit and the voltmeters used as an extra check.

The low voltage side of potential transformers should always be permanently and effectively connected with ground.

Where the type of design and method of installation require it, insulated tongs should always be used in connection with the removal and installing of potential transformer fuses. Where the high tension voltage is such that rubber gloves would offer protection, they should always be worn while fuses are being changed.

10. *Time Clock Switches.* Where time switches are mounted on poles and other structures, they shall be attended only by qualified linemen.

Where time switches are provided with high voltage connections, a lineman should always wear his rubber gloves in winding, resetting and otherwise maintaining the clocks.

11. *Killing of Lines and Equipment.* Where the voltage of the lines or equipment is such that it would be unsafe to work on them alive; where the lines and equipment to be worked on are installed in a congested condition; or where the lines or equipment are located so close to high tension lines as to make work on the former unsafe, the high tension lines in question should be killed and effectively grounded during the whole of the time when men are working on, or adjacent to, these lines. Before high tension lines and equipment are disconnected from service to permit the making of repairs, replacements and additions, the necessary holdoff arrangement should be made as far in advance as possible for the removal of these lines and equipment. (See Section IV, Holdoffs.)

IX. Special Linemen's Tools (See Section II, Tools)

1. *Canvas bag* for raising and lowering tools, small pole equipment, gloves, axes, etc., should be made without any metal parts. The use of this bag will prevent

dropping materials. Bag should be kept free from broken porcelain or sharp metal while hoisting rubber gloves.

2. *Hand lines* should always be dry and should never have wire reinforcement. Hand lines should be at least twice as long as the height of the highest cross arm on the system. No metal wire and no metal hooks should be used in the making up of hand lines.

Where it is necessary to connect two hand lines permanently, a splice should be made. No metal wire or clamps should be used in making the splice. The strength of the splice should not be less than the strength of any part of the line. Knots, friction tape, cord or marlin should not be used in joining the two parts of the line. Splices should not be bulky. Each end of the line should be tied well to prevent unraveling of the strands.

A hand line should be strong enough to safely lower a man from a pole. Only bowline knot or safety belt should be used for this purpose, never a slip noose.

Hand lines with worn or frayed parts should be scrapped immediately and replaced with hand lines which are in good condition.

Hand lines should be carried up a pole uncoiled and attached to the back of the body belt. When a lineman is climbing with a hand line, he should take care to prevent the hand line catching on pole attachments.

Dry hand lines should always be used in connection with stringing wires where these wires may come into contact with high voltage lines or with lines which may themselves be crossed with high voltage lines.

Hand lines should not be pulled over sharp bends, sharp edges, live wires or surfaces with splinters.

Hand lines should be kept free from solder, oil, grease, snarls and knots.

When hand lines are not in use, they should be rolled up and stored in the truck. (This applies except when hand lines are being dried out.) Hand lines should never be allowed to lie on the street or highway.

Where hand lines are served out on poles, at least one groundhand should be stationed at the foot of the pole to take care of the loading and unloading of the hand line, and to see that the ends of the hand lines are kept free of all street and highway traffic.

Hand lines should not be stored while they are wet.

Hand lines should be kept dry. In wet weather they should be kept under cover when not actually in use, and when they become wet, in use, should be laid aside to dry and replaced with dry lines.

One hand line should be kept in reserve and maintained dry at all times, for use in case of possible rescue of a lineman from a pole. In dry weather this line should be strung over the top cross arm on the pole. In wet weather the hand line should be kept in a protected part of the truck, where it will not be liable to become wet. Where a line gang is working on several poles, more than one hand line should be provided for use in connection with rescue after electric shock.

3. *Pike poles* should have sharp gaffs to be set well into pole. Handles should be sound and free from splinters.

4. *Dead Men.* Yokes should be free from cracks and well secured to top of pole. Poles should be sound and free from splinters. Bottom of pole should be securely fitted with a sharp spike.

5. *Measuring Rules.* Never use metal tapes, rulers or cloth tapes with metal strands or wood rulers with metal ferrules on standing poles. Dry hand lines or wood molding may be used, and then measured by tape on the ground.

6. *Axes.* Hand axes should seldom be used on standing poles. When use is unavoidable, raise and lower them in canvas tool bags; never carry them in hand or belt.

7. *Saws.* Avoid use of full length saws among wires, as short circuit may be caused.

8. *Platforms.* Linemen should descend from platform

before tower wagon is moved in traffic or from job to job. Tools should not be stored on platforms. Tower wagon should travel with lowered platform.

9. *Ladders.* Linemen should not lean widely from ladders. Ladders should not be set up on trucks or rigs which may be moved while lineman is on ladder. In walk- or roadways, foot of ladders should be guarded. On icy footing ladders should be well stayed. Ladders should not be shifted while lineman is aloft. (See also Section II, Tools.)

10. *Flashlights.* For use on poles, hand flashlights should be insulated and have insulated handles for raising and lowering by hand line.

11. *Soldering Equipment.* Keep soldering tools on ground when not in use. Take care not to drop hot solder. Use a solder catcher. Station a guard to warn traffic. Hot solder will injure rubber gloves, hand lines, canvas bags and other tools.

12. *Furnaces.* Gasoline and kerosene should be stored in approved, marked, safety type containers. Furnaces must not be lighted in inclosures, such as vault manhole, truck, etc. Furnaces must have guards and windshields on windward side. Leave open on leeward to prevent overheating.

13. *Belt tools* must be well secured in belt. Only pliers, screwdriver and connectors should be carried. All other tools should remain below until needed, then hoisted in bag. Tool keepers must not be of metal.

14. *Screwdrivers* with full length metal tang or shank through handle should not be used for electrical work.

15. *Insulated tools,* such as pliers, screwdrivers, wrenches, etc., should not be used without rubber gloves.

16. *Climbers.* The leather straps should be treated occasionally with neatsfoot oil to keep the leather pliable and soft. Straps should be inspected frequently and should be maintained in good condition at all times.

Straps which cannot be properly repaired should be replaced immediately.

The use of pads is recommended. They should be maintained in satisfactory condition, and when they become worn should be replaced.

The gaffs or spurs should be maintained sharp. They should be filed so as not to change angles of gaff surfaces. Where gaffs are worn so that they cannot be made to grip wood easily, they should be replaced with new ones. (In some cases manufacturers are able to replace gaffs in a satisfactory manner. Linemen should never attempt to make these repairs themselves.)

Each lineman should be equipped with a pair of satisfactory climbers, and he should use no others. Climbers should not be loaned or borrowed.

When climbers are not in use, they should be stored in a separate compartment in the rig or truck. They should never be placed in the rubber glove or rubber goods compartment. They should be wiped clean and dry before they are stored.

When climbers are being stored. they should be wrapped in pairs and fastened with their straps.

Climbers should not be worn:

(a) When linemen are traveling to and from a job.
(b) When linemen are piking poles.
(c) When linemen are on the ground for a great length of time.

While linemen are standing on rubber mats covering transformers, and while they are standing or walking about on cross arms on which there are rubber mats, rubber protectors and similar portable protective insulation, they should use care that the gaffs of the climbers do not puncture the surface of the portable protective insulation.

In climbing poles, linemen should be careful to put the spurs in sound wood only and to avoid all knots, loose wood, checks, cracks, decayed spots, nails, ground wires

and similar attachments. A lineman should so use his spurs as to prevent the possibility of their cutting out.

When it is necessary to climb ice- or sleetcovered poles, special care must be taken to seat the gaffs in the wood of the pole securely, so as to avoid cutting out.

Where steps are provided, they should always be used.

In coming down a pole without steps, a lineman should always use his climbers. He should not jump or "coast."

In working on a pole, a lineman should be careful in using his climbers so as not to injure any other linemen working nearby.

17. *Belts.* The Accident Prevention Committee's specifications are recommended for linemen's belts. It is suggested that all new belts be purchased in accordance with these specifications, and that old belts be repaired to conform to them. These specifications are given in the N E L A Proceedings, Vol. 81, 1924, pp. 675-679, inclusive.

Each employe authorized to climb should be equipped with a complete belt (body and safety belt), and he should use no other.

Linemen's belts and safety belts should be used for no other purpose than that for which they are intended. They should not be used as slings for hoisting materials. In emergencies, as in cases of electric shock, dry hand lines may be attached to a lineman's belt, and the belt used in connection with lowering him.

In going to jobs, linemen's belts should be stored in a satisfactory way in proper compartments on the truck or rig to protect them and to prevent them from being cut by tools, rubbed by files and from being caught under heavy line material. At night, body and safety belts should be stored carefully in compartments assigned for their storage on trucks and rigs or in other suitable places, where no other equipment will be stored.

Body and safety belts should be inspected carefully periodically for conditions of: leather, leather near the holes, rivets, stitches, buckles, "D" rings, snaps.

Belts which are weak or defective in any respect should not be used.

When repairs are necessary, they should be made immediately. Belts which have been repaired must be re inspected after the repairs have been completed. In case the repairs have not been made in a satisfactory manner, the belt should be withheld from use until the necessary repairs have been made properly, or until a new belt has been provided. Only first-class material should be used in making repairs to linemen's belts.

The leather of a lineman's belt should be treated occasionally with neatsfoot oil to keep it soft and pliable.

No more holes than are absolutely necessary should be cut or punched into a body belt. Holes weaken the leather

The attachment of metal parts to body belts should be avoided wherever possible. Metal chains and too keepers (dogs) should not be used. In their places there should be used leather or rawhide strings with hard wood or fiber keepers.

"D" rings should be placed so that they will be supported from the inside of the body belt. A lineman will then be less liable to fall in case the "D" rings pull out

Care must be taken by linemen in the attachment of snaps to "D" rings. Care must be taken that the "D ring is within the hook, and that the keeper of the snap is closed fully before any weight is applied to the safety belt.

After a safety belt is snapped in place, a lineman should test it by carefully throwing the weight of his body against the safety to make sure that it is properly fastened before he undertakes any work. While this test is being made, the lineman should have his hands around the pole or other support, so that he may readily grasp the support in case the safety should pull out. This test should be made each time the safety belt is used in a new position.

Safety belts should be so secured that there will be no

possibility that they will cut out by being accidentally pressed against line equipment.

Safety belts should not be supported from insulator pins, insulators, line wires or cross arms which may be weak or rotted. They should not be attached to vertical braces, cross arm or transformer braces. They should not be attached to a pole close to a guy where the guy is furnished with pole plates or guy hooks. Safety belts should not be attached to pole steps or trimmers' hooks. The safety belt must not be secured to cross arms and similar equipment which are being removed.

When the safety belt is being put in place, care must be taken that it is not twisted and that it does not foul material which will give way when strain is applied.

Snaps on safety belts should be closely inspected for defective and tight jaws and for weak or defective keeper springs. Snaps should also be inspected for cracks in the metal.

18. *Rubber goods* should not be put away wet. If it is necessary to put away wet rubber goods at night, they should be dried thoroughly the following day.

Oil should not be allowed to come into contact with rubber goods. Where oil falls on rubber surfaces, it should be removed immediately.

Rubber goods should not be stored in hot places.

On trucks, rubber goods should not be carried in compartments with tools or other equipment.

Rubber goods should not be carried in linemen's pockets with tools or other equipment.

Rubber goods should not be left on the ground. While they are not in actual use on the pole, they should be stored in the proper compartment in the truck.

Rubber blankets should be rolled and not folded. When they are being rolled, their surfaces should be brushed clean to prevent dirt from being imbedded in the surface of the rubber.

Where rubber blankets, line protectors and similar insulation are installed aloft, linemen walking across the

cross arms should be careful not to spur these protectors and blankets with their climbers.

Rubber hose should be dried before it is stored. It should be laid in a flat position; no part of the hose should be strained.

Rubber coats should preferably be hung on hangers when they are being stored. At other times they should be rolled up, but not folded.

All portable protective insulation should be inspected frequently and regularly for defects. It should also be subjected to electrical breakdown tests periodically. Where defects are found, the piece should be marked with a rejection tag and sent to the storeroom for replacement. New pieces should be electrically tested for breakdown before they are assigned to the line crews.

Portable protective insulation should always be installed before work on live parts, of or in excess of 300 v to ground, is undertaken. Wires and equipment, which are liable to be at ground voltage, should also be protected with portable protective insulation. In wet weather lower voltage lines and equipment should be protected, as may be necessary.

In locating portable protective insulation at the working position, the lineman should first apply this insulation to all nearby points and he should then continue to apply the insulation progressively in all directions, until the most distant point requiring insulation has been protected—that is to say, a lineman should always be protected while he is applying portable protective insulation. Rubber gloves should always be worn while portable protective insulation is being installed.

In the removal of portable protective insulation from wires and equipment, the reverse order should be maintained. A lineman should remove the most distant piece of insulation first, and remove the nearest piece of insulation last, in such a way that he will be at all times protected. Rubber gloves should be worn at all times while portable protective insulation is being removed.

19. *Rubber Gloves.* Where rubber gloves are used with leather outer gloves or cotton under gloves, they must not be put away until they have been separated from the leather outer gloves and the cotton under gloves; however, care should be taken not to use lightweight rubber gloves, designed only for use with outer protectors, without such protectors.

A lineman should not put his rubber gloves into his coat or trousers pocket, where there may be tools and line material. Gloves carried in this way are liable to injury.

While the gloves are not being used on the job, they should be stored in a separate compartment on the truck. No tools or line material should be stored in this compartment. Rubber gloves should be available at all times when the lineman needs them on the job.

At each job, before a lineman puts on his rubber gloves, he should test each glove mechanically for cuts and weak spots by rolling it up tightly, beginning at the gauntlet; he should notice if any air escapes through the palm, the thumb or the fingers of each glove. This is usually called the "air" test. Gloves which show weak spots or air leakage in this test should not be used for voltage protection.

Rubber gloves should be subjected to an electrical breakdown test periodically.

When rubber gloves become defective while they are in service, they should be immediately exchanged for good gloves. (See Section II, Tools.)

Cotton gloves may be worn under the rubber gloves; their use may be found to make the rubber more comfortable.

To protect gloves from injury, leather gloves may be worn over the rubber gloves. Protective leather gloves may be worn over the rubber gloves when wires are being spliced, when solder is being handled, when it is necessary to move about in the working position, when line wires are being tied-in on insulators, and when

any other work is being done where the rubber gloves would be liable to injury. Lightweight gloves should never be used without their protectors.

Rubber gloves must not be worn while linemen are going to and from work in a rig, truck, or other conveyance.

Rubber gloves should not be worn for those ground jobs where the possibility of accidental contact with live wires and equipment does not exist.

Some companies require linemen to put on rubber gloves (using leather outer protectors) before leaving ground to climb poles. The reason is that serious accidents have been sustained while placing safety belts after arrival to working position, or because men forgot to put on gloves just before danger position was reached. These companies require gloves to be worn from the time of starting to climb until men again return to the ground. Violation of rule entails severe penalty.

Other companies, somewhat in the majority, require men to climb without gloves until just below the first high or low voltage power conductor. Their reason is that, even with leather protectors, splinters may injure gloves and destroy insulation. There is also some hazard in using the hands to steady body while climbing, if covered with two movable thicknesses.

These conflicting practices are so steadfastly defended that both are described here without attempt to make a choice.

Rubber gloves must be worn by a lineman while he is putting portable protective insulation on line conductors and pole equipment.

A lineman must wear his rubber gloves while he is removing portable protective insulation from line conductors and pole equipment.

Rubber gloves must be worn by a lineman when he is making tests on the high tension and low tension sides of transformers, when they are being connected in cir-

cuit for the first time, when they are being tested, and when they are being inspected for burn-outs.

All linemen and trouble men should wear rubber gloves while they are removing and replacing fuses and cut-outs on primary distribution circuits.

Linemen should wear their rubber gloves while they are stringing wire near to live lines and live equipment exceeding 300 v to ground.

Some companies, however, also require use of gloves when working on live low voltage secondaries below 300 v. (See Section II, Tools.)

ACCIDENT PREVENTION LITERATURE

NOTE New publications of the National Electric Light Association are appearing continuously A complete list of publications may be obtained from headquarters A standing order for copies of new reports as they are issued may be placed with the National Headquarters at 420 Lexington Avenue, New York City

The following publications are particularly pertinent to the subject of construction:

Accident Prevention Committee

"Suggestion Systems." (Publication No. 289-112.)

"Temporary Safety Grounding." (Publication No. 278-4.)

"How to Set Up an Accident Prevention Organization." (Publication No. 267-94.)

"Accident Prevention Course for Linemen." (Publication No. 24-36.)

"Resuscitation in Gas Poisoning, Electric Shock and Drowning." (Publication No. 289-70.)

"Resuscitation by the Prone Pressure Method." (Publication No. 289-41.)

"First Aid Talks." (Publication No. 25-70.)

Overhead Systems Committee

"Construction and Maintenance Equipment and Methods." (Publication No. 08.)

Meter Committee

"Inspection, Retest and Use of Electrician's Rubber Gloves." (Publication No. 055.)

Underground Systems Committee

"Underground Systems Reference Book." (Publication No. 050.)

Other Safety Publications

Many safety publications are available which are of practical value to construction men. The following are recommended as special studies of their subject:

Boiler and Boiler Rooms

American Society of Mechanical Engineers. The Boiler Code Committee, "Rules for the Construction of Stationary Boilers and for Allowable Working Pressures," 1924.

National Safety Council, "Boiler Rooms," 1923. (Safe Practice 3.) "Equipment and Operation of Steam Boilers," 1924. (Safe Practice 49.)

Consult also state rules and regulations.

Compressed Air Machinery and Equipment

National Safety Council, "Compressed Air Machinery and Equipment," 1921. (Safe Practice 47.)

Construction

Associated General Contractors of America, "Manual of Accident Prevention in Construction," 1927.

National Safety Council, "Safe Practices and Construction Work," 1926. (Safe Practice Cn 1.) "Uniform Accident Statistics for Construction Companies," 1922. "Practical Methods for Reducing Fatigue," 1922. (Safe Practice 50.)

First Aid

Johnson and Johnson, "First Aid and Medical Service in Industry," 1928.

Lynch, Charles, American Red Cross "Abridged Text Book on First Aid," 1925. (General edition.)

National Safety Council, "Caring for Injured Worker," 1928. (Safe Practice 82.)

United States Bureau of Mines, "Manual of First Aid Instruction for Miners," 1921. Government Printing Office.

Handling Materials

National Safety Council, "Handling Materials," 1927. Parts 1 and 2. (Safe Practice 54 and 55.)

Housekeeping—Shop

National Safety Council, "Industrial Housekeeping," 1926. (Safe Practice 45.)

Maintenance and Repair Men

National Safety Council, "Safe Practices for Maintenance and Repair Men," 1926. (Safe Practice 70.)

Organization

National Safety Council, "Industrial Safety Organization," 1928. (Safe Practice 42.)

De Blois, L. A., "Industrial Safety Organization," 1926 McHill Book Co.

Public Utilities

National Safety Council, "Protection of the Public," 1927 (Safe Practice P.U. 1.)

Rutland, C. J., "Causes and Remedies of Public Utilities Accidents," 1928. National Safety Council.

Respirators, Gas Masks, Helmets

National Safety Council, "Respirators, Gas Masks and Breathing Apparatus," 1925. (Safe Practice 64.)

Resuscitation

National Safety Council, "Instructions for Administering Prone Pressure Method of Resuscitation," 1926.

Rope

Keator, E. A., "Practical Hints for the Use of Wire Rope," 1922.

National Safety Council, "Manila and Wire Rope," 1927 (Safe Practice 26.)

United States Bureau of Standards, "Non-destructive Testing of Wire Hoisting Rope," 1926. Government Printing Office. (Technical Paper 315.)

Safety Supervisor

National Safety Council, Schools for Safety Supervisors, 1923.

Subjects for Lessons

1. Safety and manager.
2. Construction and design of safeguards.
3. Plant conditions.
4. Reaching the foremen.
5. Bulletin boards.
6. Workmen's inspection committees and meetings.
7. Eye protection and safe clothing.
8. Electrical hazards.
9. Fire protection in relation to safety.
10. Plant sanitation.
11. First Aid.
12. The new employe.
13. Accident records.
14. Qualifications of a safety engineer

Tools

National Safety Council, "Hand Tools," 1924. (Safe Practice 41); "Portable Electric Hand Tools," 1927. (Safe Practice 76.)

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The following individuals and companies have materially aided in the preparation of this report by contributing publications and data which the committee gladly acknowledges. The committee has not investigated the original source of this material, and our acknowledgment is to the source from which we obtained the data.

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BABCOCK & WILCOX COMPANY, Boiler Erection Data.

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DEPARTMENT OF LABOR AND INDUSTRY, COMMONWEALTH OF PENNSYLVANIA, "Safe Practices Recommendations."

DUQUESNE LIGHT COMPANY, "Safety Rules and Instructions."

MCCLINTIC-MARSHALL COMPANY, Various tables.

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R. D'OLIVE, "Characteristics of Hand Fire Extinguishers."

PACIFIC GAS & ELECTRIC COMPANY, "Safety Rules for Employees, Electric Construction and Operation."

PUBLIC SERVICE ELECTRIC & GAS COMPANY, "Rules and Regulations for Employees."

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TRAVELERS LIFE INSURANCE COMPANY, "Safety in Building Construction," Third Edition, Revised.

UNITED ENGINEERS & CONSTRUCTORS, INC., "Field Manual—Safety Section."

UNITED STATES BUREAU OF MINES.
UNITED STATES STEEL CORPORATION, "General Requirements for Mill Scaffolds."
AMERICAN ENGINEERING STANDARDS:

A11-1921	Code of Lighting Factories, Mills and Other Work Places.
A14-1923	Safety Code for Ladders.
A17-1925	Safety Code for Elevators and Escalators.
B72-1926	Safety Code for the Use, Care and Protection of Abrasive Wheels.
B15-1923	Safety Code for Mechanical Power Transmission Apparatus.
C1-1926	National Electrical Code.
C2-1922	National Electrical Safety Code.
M4-1922	Specifications for the Testing and Use of Permissible Explosives.
X2-1922	Safety Code for the Protection of the Heads and Eyes of Industrial Workers.
A9-1927	Building Exits Code.
Z12-1926	Safety Code for Explosive Dusts.
D4	Automobile Brakes.

U. S. GOVERNMENT.

No. 208	Circular of Bureau of Standards—Wire Rope.
No. 61	Federal Specifications Board, U. S. Government Standard Specification—Manila Rope.

N. Y STATE DEPARTMENT OF LABOR, ALBANY, N. Y.

No. 126	Special Bulletin. Analysis of Accidents.

The National Electrical Safety Code is available as a complete unit, as "Handbook No. 3" of the Bureau of Standards. Parts 1, 2, 3, 4 and 5 are available separately as Handbooks No. 6, 10, 7, 8 and 9, respectively, of the Bureau of Standards.

Copies of American Engineering Standards may be purchased from the American Engineering Standards Committee, 29 West 39th Street, New York City.

U. S. Government publications and the National Electrical Safety Code may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

APPENDIX

The Prone Pressure Method of Resuscitation

Follow These Instructions Even If the Patient Appears Dead

As soon as possible feel with your fingers in the patient's mouth and throat and remove any foreign body (tobacco, false teeth, etc.). If the mouth is tight shut, pay no more attention to it until later. Do not stop to loosen the patient's clothing, but immediately begin actual resuscitation. Every moment of delay is serious. Proceed as follows with:

Standard Technique

(1) Lay the patient on his belly, one arm extended directly overhead, the other arm bent at elbow and with the face turned outward and resting on hand or forearm, so that the nose and mouth are free for breathing. (See Fig. 1.)

(2) Kneel, straddling the patient's thighs, with your knees placed at such a distance from the hip bones as will allow you to assume the position shown in Fig. 1.

Place the palms of the hands on the small of the back with fingers resting on the ribs, the little finger just touching the lowest rib, with the thumb and fingers in a natural position, and the tips of the fingers just out of sight. (See Fig. 1.)

(3) With arms held straight, swing forward slowly so that the weight of your body is gradually brought to bear upon the patient. The shoulder should be directly over the heel of the hand at the end of the forward swing. (See Fig. 2.) Do not bend your elbows. This operation should take about two seconds.

(4) Now immediately swing backward so as to completely remove the pressure. (See Fig. 3.)

(5) After two seconds, swing forward again. Thus repeat deliberately twelve to fifteen times a minute the double movement of compression and release, a complete respiration in four or five seconds.

(6) Continue artificial respiration without interruption until natural breathing is restored, if necessary, four hours or longer, or until a physician declares the patient is dead.

Fig. 1—Position in Which Patient Should Always Be Placed and Kept Until Conscious, Also First Position for Operator Starting Artificial Respiration

Fig 2—Second Position of Operator Giving Artificial Respiration.

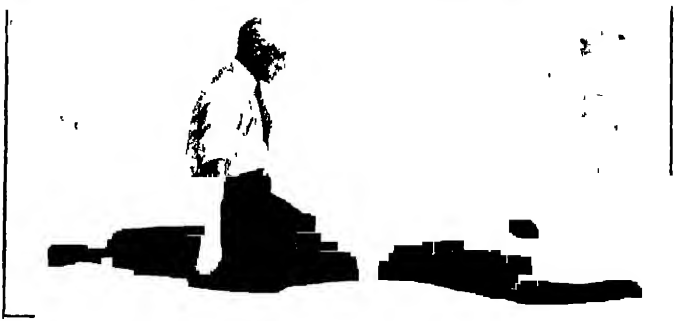


Fig. 3—Third Position of Operator Giving Artificial Respiration.

(7) As soon as this artificial respiration has been started and while it is being continued, an assistant should loosen any tight clothing about the patient's neck, chest or waist. *Keep the patient warm* Do not give any liquids whatever by mouth until the patient is fully conscious.

(8) To avoid strain on the heart when the patient revives, he should be kept lying down and not allowed to stand or sit up If the doctor has not arrived by the time the patient has revived, he should be given some stimulant, such as one teaspoonful of aromatic spirits of ammonia in a small glass of water, or a hot drink of coffee or tea, etc. The patient should be kept warm.

(9) Resuscitation should be carried on at the nearest possible point to where the patient received his injuries. He should not be moved from this point until he is breathing normally of his own volition and then moved only in a lying position. Should it be necessary, due to extreme weather conditions, etc., to move the patient before he is breathing normally, resuscitation should be carried on during the time that he is being moved.

(10) A brief return of natural respiration is not a certain indication for stopping the resuscitation. Not infrequently the patient, after a temporary recovery of respiration, stops breathing again. The patient must be watched, and if natural breathing stops, artificial respiration should be resumed at once.

(11) In carrying out resuscitation it may be necessary to change the operator. This change must be made without losing the rhythm of respiration. By this procedure no confusion results at the time of change of operator and a regular rhythm is kept up.

EXPLANATORY NOTES

I—General Points to Be Observed in All Cases Requiring Resuscitation

Take Care of the Patient

An unconscious person becomes cold very rapidly, and chilling means a further strain on a vitality already weakened. Experience has shown that the cold to which the victims of gassing, electric shock, or drowning are often carelessly exposed is probably the most important cause of pneumonia, and this disease is the most dangerous after-effect of all these accidents. As far as possible keep the patient covered and warm both during and after resuscitation. Use hot pads, hot water bottles, hot bricks, radiant heaters or other similar means, but remember that an unconscious man has no way of telling you when he is being burned.

Do not permit the patient to exert himself. If it should be necessary to move him, keep him lying down.

Medicines and Medical Help

Never give an unconscious man anything to drink. It may choke him. Medical science knows no drug which of itself will start the breathing in a patient whose breathing has ceased.

There is great danger of prematurely ceasing resuscitation. Breathing has been reestablished after eight hours of resuscitation in cases of electric shock and of gas asphyxiation. Therefore, the ordinary and general tests for death should not be accepted, and any doctor should make several very careful examinations and be sure specific evidence, such as the onset of rigor mortis, is present before the patient is pronounced dead and resuscitation is stopped.

II—Gas Poisoning and the Inhalation Treatment

What Carbon Monoxide Does

The reason that automobile exhaust gas, the gases from coal heating furnaces, the smoke from fires, producer gas, coke oven gas, blast furnace gas, carburetted water gas,

coal gas and other manufactured gases are poisonous if actually breathed is that they all contain carbon monoxide.

When carbon monoxide is breathed it combines with the blood. The more carbon monoxide there is in the blood, the less oxygen the blood will hold.

The gas victim becomes asphyxiated just as if he were being gradually choked to death. As low as one-tenth of 1 per cent of carbon monoxide, or even less, in the air will kill a man in time; 1 per cent will kill in a few minutes.

If the patient does not die in the gas but is removed to fresh air, the carbon monoxide leaves the blood in a few hours. The quicker it is breathed out of the blood, the better are the chances of recovery. If the asphyxiation has not been too long or severe, and the first aid treatment has been prompt and correct, the patient will recover completely.

Protect Yourself

Do not breathe gas yourself even for a short time. If it does not overcome you, it will cut down your strength. If you have to go into gas to get a man out, remember that nobody is immune. Protect yourself.

A handkerchief tied about the nose and mouth is not a gas mask; many have died in the belief that it is. It does not stop carbon monoxide; it simply filters off the irritating fumes in smoke, but carbon monoxide itself does not irritate the throat and has no smell. It gives no warning. It often paralyzes the legs first, and so suddenly that the man even though conscious may fall down, and cannot walk or crawl.

If you must go into gas or smoke wear a mask equipped with an air hose, or an oxygen breathing apparatus.

Get the Man Out of Gas

When a man is overcome by gas, the first thing to do is to get him into fresh air quickly. Fresh air does not mean out of doors in cold weather. Many men have walked from a warm room containing gas to collapse in the cold outside air. Take the patient to a room free from gas and comfortably warm. Be quick, but do not be unnecessarily rough. Remember you are dealing with a human being.

If the patient is not breathing or is breathing weakly,

start artificial respiration at once and have someone else telephone the utility company for an inhalator to be used in conjunction with artificial respiration.

The Use of Inhalation to Drive Carbon Monoxide Out of the Blood

In gas poisoning oxygen used properly helps to drive the carbon monoxide from the blood. Sometimes the patients do not breathe well after they are brought out of the gas. In fact, some stop breathing entirely. Even those who breathe normally often cannot get the gas out of their blood fast enough to prevent their being very sick or even dying afterwards. Pure oxygen does not stimulate the breathing. For this reason it is recommended that a mixture of about 5 per cent of carbon dioxide and 95 per cent oxygen be used. The carbon dioxide content causes the patient to breathe much more deeply, and thus allows the oxygen to drive the carbon monoxide out of the blood very rapidly. The carbon dioxide also keeps the breathing from stopping. It starts breathing more quickly in those on whom it may be necessary to do artificial respiration. It is useless to try to give an inhalation with a tank and funnel or any such makeshift. An approved inhalator, with its oxygen-carbon dioxide tank and close fitting mask must be used.

It should be distinctly understood that the inhalator is an aid to resuscitation and does not take the place of the Prone Pressure Method. The two may be used simultaneously until the patient breathes without assistance after which the inhalation may be continued if necessary.

General Directions for Giving the Inhalation Treatment

Without interrupting the rhythm of respiration, an assistant should put the mask over the patient's nose and mouth. The lower part should go well down on the chin. Press down firmly over the nose. Try to prevent leaks.

As soon as the mask is properly applied, adjust the apparatus to give the patient an ample supply of the oxygen-carbon dioxide mixture. In any case continue the inhalation for at least twenty minutes. In severe cases the inhalation should be prolonged. In using the inhalation treatment, the patient should be kept in the prone position, and when

treatment is prolonged a better chance for recovery is given if the head is six or eight inches lower than the feet. This position promotes the flow of blood to the heart.

III—Electric Shock

Breaking the Contact

The victim must be freed from contact with the live conductor as promptly as possible. Use a dry stick, dry rope, dry coat, or other non-conductor. Use of your own hands without protection is dangerous and may add another victim to the accident.

The Action of the Electric Current

In electric shock the current may pass through the breathing center at the base of the brain and cause this center to stop sending out the nervous impulses which act upon the muscles responsible for breathing. As a consequence breathing stops abruptly. If the shock has not been severe after a time the breathing center recovers and resumes the vitally necessary duty of sending impulses to the muscles of breathing. In such cases the immediate use of the prone pressure method substitutes this artificial breathing for the natural respiration of the patient. As has been pointed out, the current may so paralyze the breathing center as to require eight hours for recovery, and the prone method must be used unceasingly through this entire time.

Victims of electric shock of this sort are unconscious, but in them the heart and blood circulation continue. Their treatment demands artificial respiration with the greatest possible promptness. The method for giving this, and the general points for the care of such patients have been given.

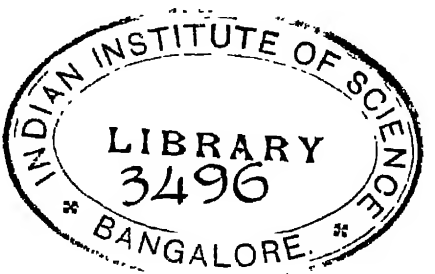
In some cases the electric current affects the heart. Under these circumstances the heart suddenly ceases to pump blood. Many cases of electric shock escape this heart effect, and even an experienced examiner requires time to assure himself it has occurred. Consequently it is the duty of those first reaching the shocked person to give artificial respiration by the prone method at once and to continue until natural breathing is restored or until the onset of rigor mortis.

IV—Drowning

In a case of drowning favorable for resuscitation, breathing has ceased, but the heart beat and the circulation of the blood continue.

Start artificial respiration at once. The pressure you must exert is the best means of forcing water out of the lungs and breathing passages. If, during artificial respiration, the body can be placed on a door or other flat surface, so that the head and chest are six to eight inches lower than the feet, drainage of water from the air passages will be assisted and the circulation of the blood improved.

Pay particular attention to maintaining warmth. The wet body chills rapidly.



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ACCIDENT PREVENTION COMMITTEE

Engineering National Section

(Administrative Year, July 1, 1929 — June 30, 1930)

SCOPE: *The major functions of this Committee are: To promote accident prevention throughout the electric light and power industry; to study accident occurrence, cause and results; to develop and promote safe methods and practices; to promote resuscitation and first aid; to administer the Insull award for N E L A; to visé safety codes; to study fire protection in its relation to human safety.*

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M O HOWLE, Alabama Power Co, Birmingham, Ala
W E HUGHES, Rochester Gas & Electric Corp, Rochester, N Y
G A JERNIGAN, Gulf States Utilities Co, Lake Charles, La
E D KETCHAM, Central Hudson Gas & Electric Corp, Poughkeepsie, N Y
E J KREH, Duquesne Light Co, Pittsburgh, Pa
P R KUHN, Penn Central Light & Power Co, Altoona, Pa
F N LAWTON, Jersey Central Power & Light Co, Asbury Park, N J
A W LEE, Louisville Gas & Electric Co, Louisville, Ky
H C LEONARD, Virginia Electric & Power Co, Richmond, Va
J H MARTIN, Bell Telephone Co, Toronto, Can
J P MCCANN, New England Power Co, Worcester, Mass
R M MOORE, Texas Power & Light Co, Dallas, Texas
A W REID, American Gas & Electric Co, New York, N Y
R V RICKFORD, The New York Edison Co, New York, N Y
MISS ESTHER ROCKEY, The Dayton Power & Light Co, Dayton, Ohio
C J RUTLAND, Texas Power & Light Co, Dallas, Texas
IVAN SCOTT, Electric Management & Engineering Corp, Asbury Park, N J
H E SHEDD, Appalachian Electric Power Co, Bluefield, W Va
R C SOGGE, General Electric Co, Schenectady, N Y
ALEX SPEER, Florida Power Corp, St Petersburg, Fla
C C STECK, Consumers Power Co, Jackson, Mich
M R SUMNER, Duquesne Light Co, Pittsburgh, Pa
M F TREADWELL, Florida Power Corp, St Petersburg, Fla
A J VAN BRUNT, Public Service Corp of New Jersey, Newark, N J
H F WEBB, West Penn Power Co, Pittsburgh, Pa
GORDON WILSON, Utilities Power & Light Corp, Chicago, Ill

Georgraphic Division Representatives

Canadian—WILLS MACLACHLAN, 2 East Bloor St, Toronto, Can
Eastern—D L BOYLE, Pennsylvania Electric Co, Johnstown, Pa
East Central—R S METZGER, The Toledo Edison Co, Toledo, Ohio
Great Lakes—GEORGE OFF, The Detroit Edison Co, Detroit, Mich
Middle West—A A RALL, Kansas City Power & Light Co, Kansas City, Mo
New England—M L WILKINS, Twin States Gas & Electric Co, Dover, N H
North Central—J E WEBB, Interstate Power Co, Dubuque, Iowa
Northwest—J B FISKEN, Washington Water Power Co, Spokane, Wash
Pacific Coast—J R ROWE, Los Angeles Gas & Electric Corp, Los Angeles, Cal
Rocky Mountain—CHARLES DWYER, Public Service Co of Colorado, Denver, Colo
Southeastern—L M SHADGETT, Georgia Power Co, Atlanta, Ga
Southwestern—JAMES HILL, JR, Southwestern Gas & Electric Co, Shreveport, La

Manufacturers' Representatives

C B AUEL, Westinghouse Electric & Manufacturing Co, East Pittsburgh, Pa
G E SANFORD, General Electric Co, Schenectady, N Y

Accident Prevention Representation on Other National Committees

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A W LEE, Louisville Gas & Electric Co, Louisville, Ky

Engineering Administration Committee
ALEX SPEER, Florida Power Corp, St Petersburg, Fla

Hydraulic Power Committee
A G BUTLER, Byllesby Engineering & Management Corp, Pittsburgh, Pa

Inductive Coordination Committee
J B FISKEN, Washington Water Power Co, Spokane, Wash

Meter Committee
K R MACKINNON, Nebraska Power Co, Omaha, Neb

Overhead Systems Committee
G S VAN ANTWERP, Philadelphia Electric Co, Philadelphia, Pa

Power Systems Engineering Committee
W A BUCHANAN, Appalachian Electric Power Co, Welch, W Va

Prime Movers Committee
M R SUMNER, Duquesne Light Co, Pittsburgh, Pa

Special Engineering Research Committee
C R BEARDSLEY, Brooklyn Edison Co, Inc, Brooklyn, N Y

Underground Systems Committee
M ELDREDGE, Memphis Power & Light Co, Memphis, Tenn

Accident Prevention Representation to Related Organizations

Accident Statistics Committee, American Standards Association
E J KRESH, Duquesne Light Co, Pittsburgh, Pa

Home Safety Section, National Safety Council
MISS ESTHER ROCKEY, The Dayton Power & Light Co, Dayton, Ohio

Special Membership of Subcommittees

K KUEMMERLING, Nelson & Kuemmerling, Canton, Ohio
F W STRUFE, The Davey Tree Expert Co, Kent, Ohio